USER MANUAL

by

MICHEL BREMER

History of Cities and
City Planning by

CLIFF ELLIS

CREDITS

Concept and Design: Will Wright

Contributions to Design: Jeff Braun, Robert Strobel

Windows Programming: TouchGo™ Studios and AZEROTH®

Computer Artwork: Don Bayless, Will Wright, Scott Martindale

Art Direction: Jenny Martin

Title Screen: Suzie Greene

Package Design: Jamie Davison Design, Inc.

Package Illustration: Dan Cosgrove

Documentation Design: Richard Bagel, Kurt West, Christopher Yoro, David Caggiano

Documentation: Michael Bremer, Cliff Ellis

Contributions to Documentation: Tom Bentley, Steve Beckert, Bob (The Italian Scallion) Sombrio

The Maxis SimCity for Windows Team:

Producers: John Csicsery

Marketing: Sally Vandershaf

QA and Testing: Alan Barton, Chris Weiss

Customer Service: Roger Johnsen and his "posse"

Manufacturing: Val Garcia, Kim Vincent

Music: Russell Lieblich

Special thanks to: Jeff Braun, Brian Hales, Bruce Joffe, Joell Jones, Edward Kilham, Kazue Osugi and Akila Redmer

Dedicated to Cassidy and Maxine the Cow.

MAXIS

2121 N. California Blvd., Suite 600

Walnut Creek, CA 94596-3572

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Introduction

WELCOME

Enter SimCity and take control. Be the undisputed ruler of a sophisticated real-time City Simulation. Become the master of existing cities such as San Francisco, Tokyo, and Rio de Janeiro, or create your own dream city (or dream slum) from the ground up.

Whether you take over an existing city or build your own, you are the Mayor and City Planner, with complete authority.

Your city is populated by Sims–Simulated Citizens. Like their human counterparts, they build houses, condos, churches, stores and factories. And, also like humans, they complain about things like taxes, mayors, taxes, city planners, and taxes. If they get too unhappy, they move out; you collect fewer taxes, the city deteriorates.

The next few sections will explain the overall concept of SimCity and give information that will help you win Scenarios and design and build better cities.

ABOUT SYSTEM SIMULATIONS

SimCity is the first of a new type of entertainment/education software, called **System Simulations**. We provide you with a set of **Rules** and **Tools** that describe, create and control a system. In the case of SimCity the system is a city.

The challenge of playing a **System Simulation** game is to figure out how the system works and take control of it. As master of the system, you are free to use the TOOLS to create and control an unlimited number of systems (in this case, cities) within the framework and limits provided by the **Rules**.

In SimCity, the **Rules** to learn are based on city planning and management, including:

Human factors - residential space and amenities, availability of jobs, and quality of life;

Economic factors - land value, industrial and commercial space, unemployment, internal and external markets, electric power, taxation, and funding for city services;

Survival factors - strategies for dealing with disasters, crime, and pollution; and

Political factors - public opinion, zoning, and keeping residents and businesses satisfied with your city and your performance.

The **Tools** provide you with the ability to plan, lay out, zone, build, bulldoze, re-zone, and manage a city.

Plan - Mapping systems give physical and demographic overviews of the entire city.

Layout - Design living and working areas, road and transit systems, and recreational areas.

Zone - Set zoning boundaries for parks, residential, commercial and industrial areas.

Build - Place roads, rails, airports, seaports, fire and police stations, sports stadiums, and power plants.

Bulldoze - Clear forests for city growth, build landfill along waterways, clear and re-zone developed areas.

Manage - Using the mapping and graphing systems, gather up-to-date information on traffic density, population trends, power grid status, pollution, crime, land value, police and fire department efficiency, and cash flow. Set the tax rate and funding levels for city services.

But the most important Tool of all is the Simulator itself. Test your plans and ideas as you watch the city grow or shrink through the immigration and emigration of industrious Simulated Citizens. Sims will move in and build homes, hospitals, churches, stores and factories in the zones you provide, or move out in search of jobs or a better life elsewhere. The success of the city is based on the quality of the city you design and manage.

SIMULATOR REACTION TIME

The simulator is a very complex multi-tasking piece of software. It is constantly performing many checks, calculations, and updates, as well as keeping watch on the mouse and keyboard to respond to your demands. When you load in a city, give the simulator a few minutes to compile its data and update the maps, graphs, population levels, etc. Some of the other times when the simulator lags behind you are when powering zones and updating the city services map after installing police and fire stations.

Simulator reaction time is also greatly affected by your computer's clock speed and type of microprocessor.

THE GOALS OF SIMCITY

There are many goals to be pursued and reached in SimCity.

SCENARIOS

Each of the eight included Scenarios is actually a game in itself, with an unlimited number of ways to win–or lose.

Each Scenario is a city that is either the victim of horrible planning or about to be the victim of a natural disaster. After you load in a Scenario, you will have a limited amount of time to correct or repair the problems. If you are successful, you will be given the key to the city. If not, you may be ridden out of town on a rail.

YOUR DREAM CITY

Perhaps the main goal of SimCity is for you to design, manage and maintain the city of your dreams.

Your ideal place to live may be a bustling megalopolis, lots of people, lots of cars, tall buildings: high-energy, high-density living. Or it may be a small rural community, or a linked group of small communities providing slow-paced country living.

As long as your city can provide places for people to live, work, shop and play, it will attract residents. And as long as traffic, pollution, overcrowding, crime or taxes don't drive them away, your city will live.

If one strategy doesn't work, try another. There are a million stories in each city, and you write them.

TUTORIAL

A WALK THROUGH YOUR CITY

After you have installed SimCity as instructed by the Quick-Start Guide, double-click the SimCity icon to start building.

Soon you will see a dialog box giving you the following choices: Start New City, Load a City, and Select Scenario. (Windows users will also have a beautiful picture of Maxine the Cow.) Click on **Start a New City**.

Windows SimMayors will be asked to name their city and select a Game Play Level. Go ahead and name your city, and select "Easy" level. You'll be given randomly generated terrain to build your city.

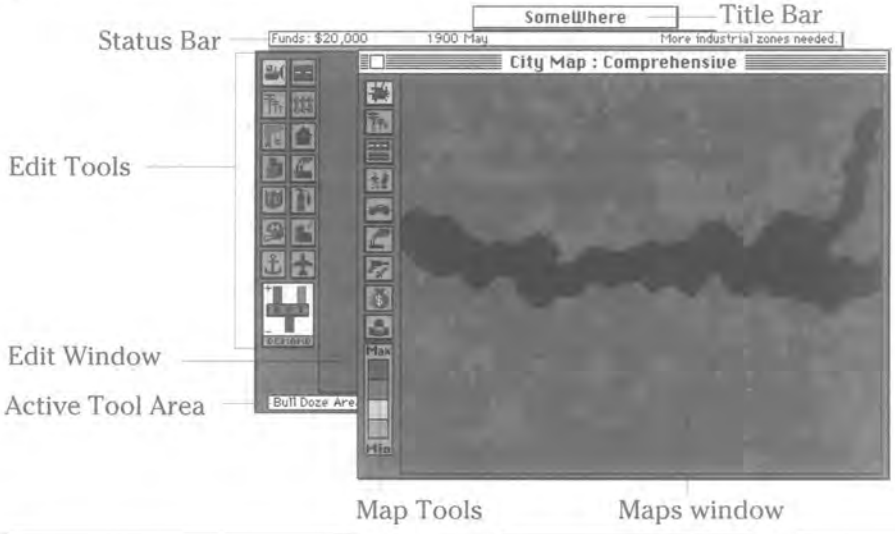
Macintosh users will see an over-view of randomly generated terrain first, and be given the choice to **Generate New Terrain** or **Use This Map**. Click **Use This Map**. Next, You'll be allowed to select a Game Play Level. Make this tutorial easy on yourself by clicking the button next to Easy, then click **OK**. Finally, you'll be able to name your city. The default name is SimWhere under Windows, and SomeWhere in Macintosh. Leave it or change it as suits your whim, then click **OK**.

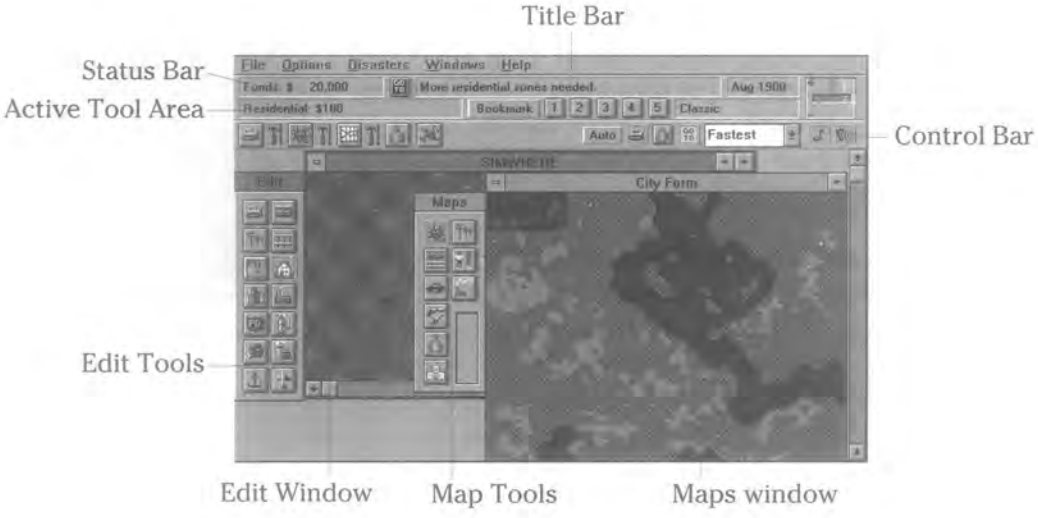
Maps Window

There are two overlapping windows for you to build your city. The one in front is the **Maps Window**. This is labeled **City Plan** for Windows users, and **City Map**: Comprehensive for Macintosh users. In both cases, you are looking down on the overall view of your entire terrain. What you see is approximately 10 miles on a side.

Windows users have a Toolbox of icons labeled "Maps." Macintosh users have a row of icons along the left side of their map window. In either case, the icons are tools that can be used to display different demographic views of your city. We'll play with them later.

The small flashing box located somewhere on the map indicates the portion of your terrain that will be visible in the Edit Window, your main work area. Click and drag the box around the map, choosing the area you wish to work on. Windows users should click on the SIMWHERE window. Macintosh users can double-click in the box Maps window to go to the Edit Window.





Edit Window

Note: The Budget Window will pop up once a year in "city time." When it does, just click on Go With These Figures.

You are now in the Edit Window, looking at a close-up view of the area in the box in the Maps Window. Windows users should note the icons in the Toolbox labeled "Edit." (The Windows Control Bar is described in the Windows section of the Manual Quick-Start-Guide.) Macintosh users should notice the icons on the left side of the Edit Window.

Each set of tools works like icons in various draw and paint programs on the market.

You can use the scroll boxes along the right side and bottom of the window to move the window quickly around the terrain. To scroll over the terrain, use the arrows on each end of the scroll bars. Macintosh users can also use the

joystick box in the upper right-hand corner of the Edit Window. Cursor key can be used to scroll.

You have three types of terrain for building your city. The brown areas are clear land, the green areas are forests and shrubs, and the blue areas are water. (In black and white, these areas are light for land, gray for forests, and dark for water). You can build only on clear land, although you can put roads, rails and power lines across water. You can clear forest and extend coastlines with your bulldozer.

To clear the terrain, click the bulldozer icon in the upper-left corner of your group of Edit Tools. The "pointer" is a small square, outlining the area that will be bulldozed every time you click the mouse. Move your bulldozer pointer over some forest land and click. The forest section under your pointer is now clear land. Now, hold the button down and move slowly across the forest. Clear a large area of land to prepare for building.

Click the house icon, then mouse back to your terrain. Your pointer is now a larger square outline. This outline indicates how much clear space you will need to create a residential zone. Clicking the mouse button in clear terrain "zones" the land.

The "R" in the center of the zone indicates that it is a residential zone. The flashing lightning symbol indicates that the zone has no power. Place a few more residential zones adjacent to the first one.

Now decide where to position a power plant in your city. Point to the power plant icon and hold down the mouse button. A small menu will appear, giving you the option of choosing a coal or nuclear plant. For now, choose the coal power plant. Then place it in some open space near your residential zones.

If your power plant is not directly adjacent to a residential zone, you will have to run a power line from your power plant to the residential zone. To do this, click the power line icon. Using your mouse pointer and button, lay power lines from your power plant to your residential zones. Adjacent power line sections will automatically connect themselves to one another.

Roadways and transit lines connect in the same manner.

In a moment, the flashing symbols will disappear, indicating that your zones have been powered. Any zones that are adjacent to a powered zone do not need separate power lines run to them. Soon you will see small houses start to appear. The Sims have started to move in.

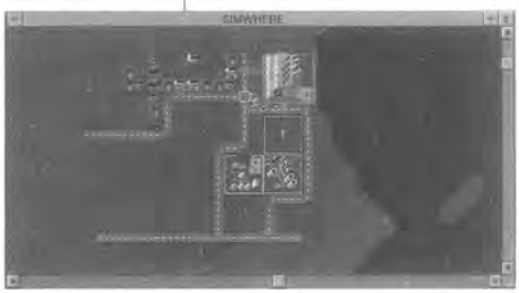
Note: When you zone land, you designate where building is allowed. It is the Sims who actually build.

Now that you have a few residential zones, you're ready for commercial and industrial areas. Select the commercial icon and place a few commercial zones near your residential ones. Then select the industrial icon and map out some industrial zones. Connect all necessary power lines.

Note: There is a delay between the time you connect power to a zone and the time the flashing lightning symbol disappears. This delay gets longer as your city grows.

Notice that when you select different icons, the icon description and its associated cost will be displayed in the Active Tool Area of the Edit Window. The message bar across the top of the Edit Window displays your total funds available. If you do not have enough money in your treasury to pay for a certain function, that icon will be "ghosted" on your screen and is unavailable for use.

Before your new city can really begin to develop, you need roads. Click on the **Road** icon and add roads from your residential housing to the commercial and industrial areas to allow the Sims to commute to work. Road sections connect themselves like Power Line sections. Once you have roads, traffic will be generated, and zones will develop.



Now select **Budget** from the Windows Menu. This is where you set the level of funding for your fire, police, and transportation departments. Click the up or down arrows to change the funding level. You can also adjust the current property tax rate. If you have no police or fire departments, they don't need funds. Click **Go With These Figures** when you are done.

Now select **Maps** from the Windows Menu. By clicking on the Map Window icon, you can see different demographic views of your city. You will need this information to build and adjust conditions in your city. For example, you can pinpoint the areas with the highest crime to determine locations for new police stations.

Additional information can be gained through the **Graphs** selection from the Windows Menu. Unlike the maps, which only show the current state of your city, the graphs give you a record of the past so you can gauge trends and cycles.

This is all the basic information you need to run SimCity, but we suggest reading on. The User Reference section explains in detail how to use each program function. Inside SimCity explains the inner workings of the simulator, and gives some hints and tips for using it. There is also an essay, on *The History of Cities and City Planning*, and a bibliography for serious City Planners.

TERRAIN

There are three types of terrain in the Edit Window: Open Land, Trees, and Water. Open Land is where you can zone and build. Depending on the type of monitor and graphics card you have, it is brown, or as a very light shade with speckles.

Trees and Forests are green, or a medium shade. You cannot zone or build on trees. You may Bulldoze trees and forests to turn them into clear land. While some bulldozing is necessary, clearing away too much green area will result in lower property values.

Water is blue, or a dark shade. You cannot zone or build on water. You must bulldoze coastlines to create landfills before you can build or zone there. Roads, rails and power lines can be built across water, with no turns or intersections.

THE KEYBOARD

Keyboard equalivants for menu items are displayed next to the item in the menu. For information on an area in your city, put your cursor over the area, hold down the "Q" Key, and click the mouse button.

MENUS

File Menu

LOAD GRAPHICS brings up a dialog box that lists available Graphics Sets, and allows you to change the architecture of your city. Graphic Sets (Ancient Cities and Future Cities) are an optional add-on to SimCity Classic. Call Maxis for information on where to buy these Alternate Graphic Sets.

LOAD SCENARIO brings up a menu of Scenarios, which are special cities with problems to solve.

START NEW CITY generates a new, empty terrain, and clears existing city (if any) from memory. You will be given a chance to go back and save the old city first. You will also be able to set the Game Play Level, and name your city.

LOAD CITY brings up a File Loading Dialog Box and lets you load a previously saved city. If you have an existing city in progress, SimCity will first ask if you want to save changes to your old city before loading another.

SAVE CITY saves the scenario or city in progress to disk. Use this option to save a city under the same name and to the same place that it has already been saved. If you wish to change the name or location of a city, use the Save City As... option. The first time you choose Save City, you will be asked to name the city and indicate where to save it.

SAVE CITY AS... also saves a city in progress for later use. Use this option to save a city for the first time, or to save a previously saved city under a different name, or to a different disk or subdirectory.

NOTE: Once you have loaded a scenario, it can be saved and reloaded, like any city, without the impending disaster.

PRINT CITY Under Windows, this menu option lets you save your city as a paint file in PCX format (which will load into many paint programs, including Paintbrush, which comes with Windows). Once in the paint program, you can add street names, borders, etc. to your city and print it out.

Under Macintosh, this menu option prints your city in either of two sizes, on one page or a three-page by two-page poster. You'll need an ImageWriter or PostScript LaserWriter printer for this.

EXIT (**QUIT** on Macintosh) ends your SimCity session.

Options Menu

Most of the options set in this menu are saved with the city. When an option is active, there will be a checkmark to the left of the option.

AUTO-BULLDOZE allows you to place zones, roadways, etc. directly on top of trees and shoreline without manually bulldozing first. You will be charged the same as for manual bulldozing.

AUTO-BUDGET keeps your budget at the same percentage settings without asking for approval every year. If there isn't enough money to meet the budget, then funds will be allocated first to the Transit system, then to the Fire Department, then to the Police.

AUTO-GOTO automatically transports you to disasters and major events.

SOUND EFFECTS (**SOUND ON** for Macintosh) toggles the sound effects on and off. The simulation runs slightly faster with the sound off

ANIMATE ALL (**UPDATE ALL WINDOWS** for Macintosh) activates animation and updating in all windows. When it is not active, only the front window will be animated or updated. When this option is off, the simulation runs faster. This option is not saved with a city.

The following Option menu items are for Windows only:

MUSIC toggles the background music on and off. The simulation runs slightly faster with the music off.

SPEED brings up a sub-menu allowing you to set the simulation speed. **Fastes**t sets city time to the maximum

speed possible on your machine. **Pause** stops time. Zoning and building are possible in paused time, but there will be no city growth or evolution.

FREQUENT ANIMATION sets the frequency that the simulation stops crunching numbers and animates the screen. When this option is off, the simulation, and therefore time, will run faster.

STATUS BAR toggles the display of the **Status Bar** on and off.

CONTROL BAR toggles the display of the **Control Bar** on and off.

MINIMIZE PAUSED automatically pauses the game when it is minimized.

SAVE OPTIONS saves your current options settings to disk as the new default. The next time you start SimCity for Windows these options will be in effect.

Game Speed Menu (Macintosh only)

FAST sets city time to maximum speed

MEDIUM is the default setting, about three times slower than FAST.

SLOW sets the speed about seven times slower than FAST.

PAUSE stops time. Zoning and building are possible in paused time.

Disasters Menu

The **Disasters Menu** allows you to set natural disasters loose in your city. Use these disasters to test your ability to deal with emergencies in your city or just to release some aggression. More information on disasters, their causes, and

dealing with them is presented later.

Warning: It is a good idea to save your city to disk before you set a disaster loose–just in case.

FIRE starts a fire somewhere on the map.

FLOOD causes a flood to occur near the water.

AIR DISASTER causes a plane to crash. If there are no planes in the air, one will be generated.

TORNADO causes a tornado to appear somewhere on the map.

EARTHQUAKE causes a major earthquake.

MONSTER sets a monster loose in your city.

DISABLE eliminates the random disasters.

Windows Menu

MAPS opens the Map Window.

GRAPHS opens the Graphs Window.

BUDGET opens the Budget Window.

EDIT opens the Edit Window.

EVAL opens the Evaluation Window.

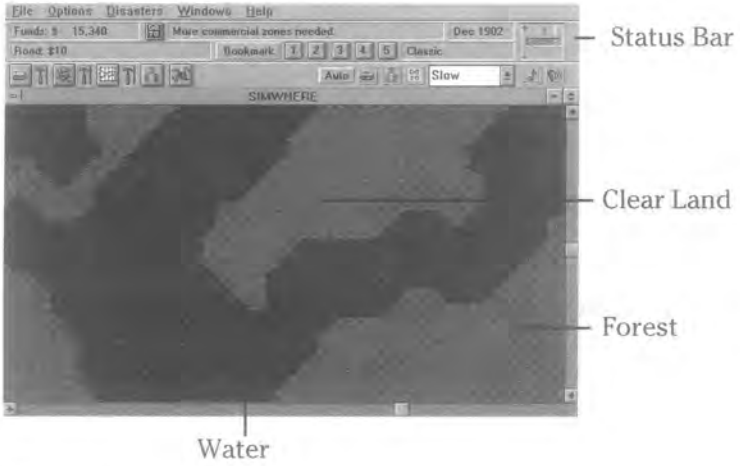
Help Menu (Windows version only)

HELP... opens the on-line Help for SimCity.

ABOUT SIMCITY brings up a screen giving fascinating and vital information about SimCity and Maxis.

EDIT WINDOW AND TOOLS

You build and zone your city in the Edit Window, using the Edit tools.



Scrolling

Only part of your city will show at any one time in the Edit Window. You can scroll to different parts of your city by using the scroll bars. (Windows users can also use cursor and Numeric Keypad keys.)

Using Tools and Placing Zones

The Edit Window has 14 different tools that you use for building and editing your city. The tools are selected by clicking on them with the mouse. (Windows users should click the left mouse button.) The active tool and its cost to use are displayed in the Status Bar. If you don't have enough funds to use a tool, its icon will be ghosted. When a tool is selected, the pointer becomes a rectangle to indicate the area of land that will be affected.

BULLDOZER clears trees and forests, creates landfill along the water, levels developed, existing zones and clears rubble caused by disasters. The Auto-Bulldoze option works on natural terrain, power lines, roads and rails, but not on zones. Bulldozing the center of a zone will destroy the whole zone. Bulldozing one section of land costs $1.

ROADS connect developed areas. Intersections and turns are automatically created. Lay continuous roads by clicking and dragging your pointer. Be careful-if you accidentally lay a road in the wrong place you will have to pay for bulldozing and rebuilding. Holding down the **Shift** key while laying roads will constrain them to a straight line.

Roads may not be placed over zoned areas. They may be placed over trees, shrubbery, and shoreline only after bulldozing or activating the Auto-Bulldoze function from the **Options Menu**. Roads can cross over power lines and rails only at right angles. Laying roads across water creates a bridge. Bridges can only be built in a straight line-no curves, turns or intersections. Shorelines must be bulldozed prior to building a bridge, unless the Auto-Bulldoze function from the **Options Menu** is active.

Roadways are maintained by the transit budget, and wear out if there is a lack of funding. The amount of yearly funding requested by the transportation department is $1 for each section of road, $4 for each section of bridge. It costs $10 to lay one section of road and $50 to lay one section of bridge.

POWER LINES carry power from power plants to zoned land and between zones. All developed land needs power to function. Power is conducted through adjacent zones. Unpowered zones display the flashing power symbol. There is a delay between the time you connect power to a zone and when the flashing symbol disappears that grows longer as the city grows larger.

Power lines cannot cross zoned land, and can be built over trees, shrubbery, and shoreline only after bulldozing, or after activating the Auto-Bulldoze function from the **Options Menu**. Holding down the **Shift** key while laying power lines will constrain them to a straight line.

Junctions and corners are automatically created. Lay continuous power lines by clicking and dragging your pointer. Power lines across water must be horizontal or vertical–no turns, curves or intersections. Power lines consume some power due to transmission inefficiencies. It costs $5 to lay one section of power line on land, $25 on water.

TRANSIT LINES create a railway system for intra-city mass transit. Lay continuous transit lines by clicking and dragging your pointer. Intersections and turns are created automatically. Holding down the **Shift** key while laying tracks will constrain them to a straight line. Tracks laid under rivers will appear as dashed lines. These are underwater tunnels, and must be vertical or horizontal–no turns, curves or intersections.

Transit lines are maintained by the transit budget. The level of funding affects the efficiency of the system. The amount of yearly funding requested by the transportation department is $4 for each section of rail, and $10 for each section of tunnel. It costs $20 per section of track laid on land, $100 per section under water.

PARKS can be placed on clear land. Parks, like forests and water, raise the land value of surrounding zones. Parks can be bulldozed as fire breaks or to reserve space for later mass transit expansion. Holding down the **Shift** key while building parks will constrain them to a straight line. It costs $10 to zone one park.

RESIDENTIAL ZONES are where the Sims live and build houses, apartments and community facilities such as schools, hospitals and churches.

Most Residential zones develop into one of four values: slums, lower middle class, upper middle class, and upper class. They can range in population density from single-family homes to high-rise apartments and condominiums. Some Residential zones will automatically develop into Churches and Hospitals. Factors influencing residential value and growth are pollution, traffic density, population density, surrounding terrain, roadway access, parks and utilities. It costs $100 to zone one plot of land as Residential.

COMMERCIAL ZONES are used for many things, including retail stores, office buildings, parking garages and gas stations. There are four values for commercial property, and five levels of growth, from the small general store to tall skyscrapers. Factors influencing the value and growth of commercial areas include internal markets, pollution, traffic density, residential access, labor supply, airports, crime rates, transit access and utilities. It costs $100 to zone one plot of land as Commercial.

INDUSTRIAL ZONES are for heavy manufacturing and industrial services. There are four levels of industrial growth, from small pumping stations and warehouses to large factories. Factors influencing industrial growth are external markets, seaports, transit access, residential access, labor supply and utilities. It costs $100 to zone one plot of land as Industrial.

POLICE DEPARTMENTS lower the crime rate in the surrounding area. This in turn raises property values. Place these in high-density crime areas as defined by your Crime Rate map. The efficiency of a station depends on the level of police department funding. It costs $500 to build a Police Station. Full yearly maintenance of each Police Station is $100.

FIRE DEPARTMENTS make surrounding areas less susceptible to fires. When fires do occur, they are put out sooner and do less damage if a station is near. The effectiveness of fire containment depends on the level of fire department funding. It costs $500 to build a Fire Station. Full yearly maintenance of each Fire Station is $100.

STADIUMS encourage residential growth, once a city has become fairly large. You may build a stadium in a smaller city without negative (or positive) effect. Stadiums indirectly generate a lot of revenue, but create a lot of traffic. Properly maintaining a stadium requires a good road and transit network. It costs $3000 to build a Stadium.

POWER PLANTS can be coal or nuclear, chosen from a sub-menu provided when you activate the Power Plant icon. The nuclear plant is more powerful but carries a slight risk of meltdown. The coal plant is less expensive, but less powerful, and it pollutes. All zoned land needs power to develop and grow. When developed land loses power, it will degenerate to barren ground unless power is restored. Connecting too many zones to a Power Plant causes brownouts.

Coal power plants cost $3000 to build, and supply enough energy for about 50 zones. Nuclear plants cost $5000 and supply electricity for about 150 zones.

SEAPORTS increase the potential for industrial growth. They have little effect in a small city, but contribute a lot to industrialization in a large city. Seaports should be placed on a shoreline. The shoreline must be bulldozed prior to zoning a Seaport, unless Auto-Bulldoze is active. Once the port is operational, you may see ships in the water. It costs $5000 to zone land for use as a Seaport.

AIRPORTS increase the growth potential of your commercial markets. Once a city starts getting large, commercial growth will level off without an Airport. Airports are large and expensive and should not be built unless your city can afford one. Position Airports to keep flight paths over water whenever possible, lessening the impact of air disasters. Once you build an Airport you will see planes flying above your city to and from the Airport. There is also a traffic helicopter that alerts you to heavy traffic areas. It costs $10,000 to zone land for use as an Airport.

THE BUDGET WINDOW

At the end of each year taxes are collected, and the **Budget Window** will appear (unless you select the Auto-Budget function). You will be asked to set the funding levels for the fire, police and transportation departments, and to set the property tax rate.

When Auto-Budget is active, all the funding levels will remain at full funding, or at your last setting. If there is not enough money to completely fund the budget, money will go to the Transit Department first, then to the Fire Department, then to the Police Department.

You can raise and lower budget levels by clicking on the little arrows that correspond to each category. A percentage indicator will display the level of funding that will be maintained if you turn on the Auto-Budget function. You may adjust your tax rate by clicking on the arrows next to the tax rate indicator. Click on "GO WITH THESE FIGURES," or hit **Return** to exit the Budget Window.

Note: When you first load in a city, all the Budget amounts will be zeroed out until the next January. This first year is a "grace period," and all City Services will be considered completely funded.

TAX RATE

The maximum tax rate you can set is 20%.

The minimum tax rate you can set is 0%.

The optimum tax rate for fast growth is between 5% and 7%.

To slow city growth without actually shrinking, set the tax rate to 8% or 9%.

The tax collection from each zone is based on the following formula:

Tax = Population x Land Value x Tax Rate x a Scaling Constant.

The scaling constant changes with the difficulty level of the game.

FUNDING LEVELS

The amount of yearly funding requested for the fire and police departments is $100 per station. Until you actually build fire or police stations, you cannot fund them. You cannot allocate more than 100% of the requested funding for fire and police departments–SimCity police officers and fire inspectors are honest and will not accept your bribes. Allocating less than the requested amount will decrease the effective coverage of the police or fire station.

The amount of yearly funding requested for the transportation department is $1 for each section of road, $4 for each section of bridge (roads over water), $4 for each section of rail, and $10 for each section of tunnel (underwater rails). You cannot allocate more than 100% of the requested funds.

Funding transportation maintenance slightly below 100% will cause slow, minor deterioration of the transit system–an

occasional pothole or bad track section. Funding between 90% and 75% will cause noticeable damage–many sections of road and rail will be unusable. Funding below 75% will cause rapid deterioration of your transit system.

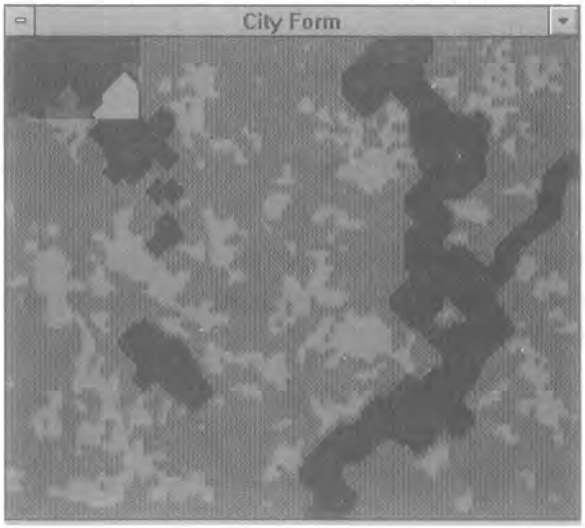
CASH FLOW

Cash Flow = Taxes Collected – Total Allocated Funds. It will be a negative number if your yearly maintenance costs are greater than your yearly tax intake.

A major difference between SimCity and a real city is that SimCity does not allow budget deficits. If you don't have the money, you can't spend it. Try not to let your city run with a negative cash flow.

THE MAPS WINDOW

The **Maps Window**, which can be opened from the Windows Menu gives you various overviews of your city.



Somewhere in the map is the **Edit Rectangle**. This rectangle shows the area of the map that is visible in the Edit Window. You can move the rectangle around the map with the mouse or cursor keys to change the area that the Edit Window displays. The rectangle will stop at the borders of your city. If the entire map isn't displayed, moving the rectangle to the edge of the window will cause the map to scroll.

Macintosh users can double-click this rectangle to open their Edit window to the area defined by the rectangle.

You may also notice letters on the map. These are markers to let you know where moveable objects are. An **"S"** marks the location of a ship. An **"R"** marks the location of a railroad train. An **"H"** marks the location of a helicopter. An **"A"** marks the location of an airplane. An **"M"** marks the location of a Monster, and a **"T"** marks the location of a Tornado.

MAPS WINDOW TOOLS AND MAPS

There are nine tools you can use on the Maps Window. Each tool shows a different view of your city. A Density Key is used when these views use colors or gray scales to show density, rate, or comparative levels of some city aspects.

The **CITY FORM MAP** shows the physical shape of your city, showing developed and non-developed areas. Use this map to plan city expansion.

The **POWER GRID MAP** shows the power network of your city. Use this map to locate unpowered zones and breaks in the power lines.

The **TRANSPORTATION MAP** is a road and rail map of the city. Use this map to examine traffic access to all parts of the city and plan further expansion of the network.

Click and hold on the **POPULATION MAPS** icon to bring up a sub-menu offering two map views.

The **POPULATION DENSITY** view displays the average number of people occupying an area each day. Use this map to locate under-utilized areas and overpopulated areas.

The **POPULATION GROWTH** view shows the most recent growth (positive or negative) of your city, and where it is occurring.

The **TRAFFIC DENSITY MAP** shows the amount of traffic on the roads. Spot traffic problems and determine where new roadways are needed.

The **POLLUTION INDEX MAP** shows levels of pollution throughout the city. Pollution is generated primarily by industry, traffic, and coal power plants.

The **CRIME RATE MAP** shows the level and location of crime in your city. Crime is calculated from population density, land value, and proximity of police stations.

The **LAND VALUE MAP** shows the relative value of land within the city limits. Land values are used to establish the amount of revenue generated by taxes.

Click and hold the **CITY SERVICES** icon to bring up a sub-menu offering views of police or fire services.

The **POLICE INFLUENCE MAP** displays the effective radius of Police Stations based on their location, power, funding levels, and access.

The **FIRE PROTECTION MAP** displays the effective radius of Fire Stations based on their location, power, funding levels, and access.

USING THE MAPS

The Map Window should be constantly referred to in all stages of city planning, building and managing. Printing the map and sketching in your plan with pencil or pen can save a lot of bulldozing and re-zoning and rebuilding.

BEFORE YOU BUILD

Use the map before beginning a new city to plan:

where you want your city center,

where you want the high-value waterfront residential areas,

where you will cross water with bridges, power lines and tunnels,

where to place power plants,

where to place large industrial sections away from the residential sections,

and the general layout of the city.

DURING CITY GROWTH

Use the map to guide your city's growth around forest areas, to preserve the trees and improve property values.

Use the transportation map along with the traffic density map to plan traffic control and expansion.

Use the city map to make sure you have the proper ratio of residential to commercial to industrial zones.

Use the pollution map to detect problem areas, and disperse the industrial zones and/or replace roads with rails.

Printing out the map in various stages of development and doing some preliminary expansion planning with a pencil can be useful. Printouts can also be used for city historical records.

DURING CITY MAINTENANCE

Use the power grid map to locate zones that have lost power.

Use the city services maps to evaluate the effective coverage of your police and fire departments.

Use the crime rate map to locate problem areas that need more police protection.

Use the pollution map to locate problem areas.

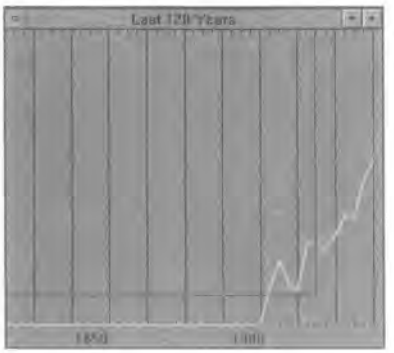
Use the transportation and traffic density maps to determine where to replace roads with rails.

Use the land value map to locate depressed areas for improvement or replacement.

Use the city map to maintain the proper ratio of residential to commercial to industrial zones.

GRAPHS WINDOW

The Graphs Window gives you time-based graphs of various city data. It is opened through the Windows Menu.



There are eight Graph Window icons, six of which select different graphs of city data. The other two select the time range the data covers.

Multiple graphs can be viewed at once. Each graph is a different color. Active icons are outlined in the same color as their corresponding data line in the graph.

THE GRAPHS ICONS

The **RESIDENTIAL POPULATION GRAPH** shows the total population in residential zones.

The **COMMERCIAL POPULATION GRAPH** shows the total population in commercial zones.

The **INDUSTRIAL POPULATION GRAPH** shows the total population in industrial zones.

The **CRIME RATE GRAPH** shows the overall crime rate of the entire city.

The **CASH FLOW GRAPH** shows your city's cash flow: money collected in taxes minus money it took to maintain your city. The line in the center of the CASH FLOW GRAPH represents a cash flow of zero. Do not build more infrastructure (roads, rails, police departments, fire stations) than you can support with tax revenues.

The **POLLUTION GRAPH** shows the overall average pollution reading of the entire city.

You may view graphs for time periods of either the last 10 years or the last 120 years by clicking on the 10 YEAR or 120 YEAR buttons.

USING THE GRAPHS

The Graphs give information on many of the same factors as the Maps, but show the information over time. Graphs are for locating trends in city life that won't be noticeable in a Map. If you look at a Map, for example the crime rate map, once every year, a very slight rise in the crime rate will not be noticeable. But on a Graph, you could easily locate the upward trend in crime because you will be viewing the levels for a number of years at the same time.

Residential, commercial and industrial population growth and/or decline can be tracked and displayed. If you notice a downward trend in any of these, refer to the User Reference Card to locate potential problems and solutions.

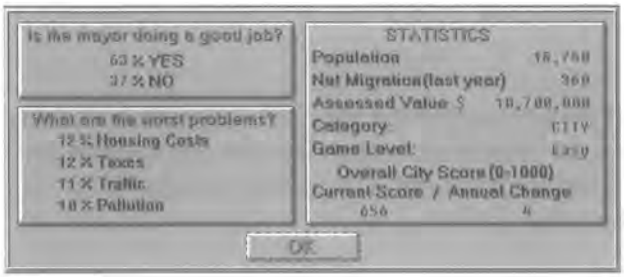
Crime rate can be displayed, revealing slight but consistent upward or downward trends.

Use the Cash Flow Graph to track your city's efficiency as it grows. If your maintenance costs are higher than your tax revenues, you will have a negative cash flow.

Use the Pollution Graph to catch rising levels of pollution before they reach a problem level.

THE EVALUATION WINDOW

The EVALUATION WINDOW gives you a performance rating.



PUBLIC OPINION is presented in poll form, rating your overall job as mayor and listing what the public regards as the city's most pressing problems. You are advised to keep your residents happy or they might migrate away, and you will be left with a "ghost town."

In general, if more than 55% of the populace thinks you are doing a good job, then you can feel secure about keeping your job.

If 10% or less of the people think something is a problem, then it's not too bad.

These are most of the problems that citizens complain about, and how to correct them:

Traffic	Replace dense sections of roads with rails
Crime	Add police stations and/or raise property values
Pollution	Replace roads with rails, disperse industrial zones
Housing	Zone more residences
Housing costs	Zone more residences in low property value areas
Fires	Build more fire departments
Taxes	Lower taxes (if you can)
Unemployment	Zone more commercial and industrial areas

STATISTICS on **Population, Net Migration** and **Assessed Value** are displayed, along with the city's **Game Level** and the **Overall City Score**. This data is calculated once a year at budget time.

POPULATION is the number of residents in your city.

The **NET MIGRATION** statistic provides a rating of the desirability of your city. If people are leaving in droves, then you know something is rotten in SimCity.

The **ASSESSED VALUE** is the combined value of all city-owned property: roads, rails, power plants, police and fire stations, airports, seaports, parks, etc. It does not include residential, commercial and industrial zones.

The **CATEGORIES** are defined by population as follows:

Village	0 to 1,999
Town	2,000 to 9,999
City	10,000 to 49,999
Capital	50,000 to 99,999
Metropolis	100,000 to 499,999
Megalopolis	500,000 and above

OVERALL CITY SCORE is a composite score based on the following factors (some positive, some negative):

MAJOR FACTORS - Crime, pollution, housing costs, taxes, traffic, unemployment, fire protection, unpowered zones, city growth rate.

MINOR FACTORS - Stadium needed (but not built), seaport needed (but not built), airport needed (but not built), road funding, police funding, fire department funding, and fires.

A large population is not necessarily a sign of a successful city. Population size does not affect the overall city score, since low population could indicate a new or growing city.

Since city growth rate does affect the overall city score, a city in which growth has been intentionally stopped for environmental or aesthetic reasons will have a slightly lower score.

DISASTERS

Disasters will randomly occur as you play SimCity. At higher game levels the disasters will happen more often. Most disasters can be activated from the **Disasters Menu**. Random disasters can be eliminated by the **Disable** option on the Disasters Menu.

FIRES can start anywhere in the city. Fires spread fairly rapidly through forests and buildings, and more slowly over roadways. Fire will not cross water or clear land.

The effectiveness of the fire department (which can be viewed in the Maps Window) is based on how close it is to the fire, and its funding levels. Fires inside this effective radius will be extinguished automatically. If you have no operational fire departments in the area, you can try to control the fire yourself. Since fire will not spread across clear terrain, you can build fire breaks with the bulldozer. Just surround the fire with clear areas and it will stop spreading and eventually burn itself out.

Note: You cannot directly bulldoze a fire.

FLOODING occurs near the water. Floods gradually spread and destroy buildings and utilities. After a while the flood waters recede, leaving behind cleared terrain.

AIR CRASHES can happen anywhere in the city if an airport is operational. This happens whenever aircraft collide with things, such as tornadoes or another aircraft. When a crash occurs, a fire will start, unless the crash is on water. A good strategy is to locate the airport away from the central city to minimize the fire damage.

TORNADOES can occur anywhere on the map at any time. Very fast and unpredictable, they can appear and disappear at a

moment's notice. Tornadoes destroy everything in their path, and can cause planes, helicopters, trains, and ships to crash.

EARTHQUAKES are the most devastating disaster. This is a major Earthquake–between 8.0 and 9.0 on the Richter Scale. It will destroy buildings and start fires. The initial damage will vary with the severity of the earthquake, and the eventual fire damage depends on your fire-control efforts.

When an Earthquake occurs, you will see the Edit Window shake for a while. When it stops, you will have to take charge and control the scattered fires. Use the bulldozer to contain the largest fires first and work your way down to the smaller ones.

MONSTER ATTACKS are provoked by high levels of pollution. A monster destroys everything in its path, starts fires, and causes planes, helicopters, trains and ships to crash.

MELTDOWNS are only possible if you are using a nuclear power plant. If a meltdown occurs, your nuclear plant will explode into flames. The surrounding area will be unusable for the remainder of the simulation due to radioactive contamination. Meltdowns are not available on the Disasters Menu.

SHIPWRECKS can occur once you have an operating seaport. They can cause fires where the ship crashes into a shore or bridge. Shipwrecks are not available on the Disasters Menu.

SCENARIOS

The Scenarios provide both real and hypothetical problems for you to deal with in seven famous (and one not-so-famous) cities. They present various levels of difficulty. Some

problems are in the form of disasters which will occur some time after you start. Other problems are more long-term, such as crime. Your task is to deal with the problem at hand as well as possible under the circumstances. After a certain amount of time the city residents will rate your performance in a special election. If you do very well you may be given the key to the city. However, if you do poorly, they just might run you out of town.

NOTE: To avoid the disaster which is tied to a scenario, save it to disk and reload the city from the saved file.

DULLSVILLE, USA 1900–BOREDOM

Things haven't changed much around here in the last hundred years or so and the residents are beginning to get bored. They think Dullsville could be the next great city with right leader. It is your job to attract new growth and development, turning Dullsville into a Metropolis by the 21st century.

Difficulty: Easy

Time Limit: 30 years

Win Condition: Metropolis

SAN FRANCISCO, CA 1906 8.0–EARTHQUAKE

Damage from the earthquake was minor compared to that of the ensuing fires, which took days to control. Fifteen hundred people died. Controlling the fires should be your initial concern here. Afterwards, clearing the remaining rubble will allow the city to start rebuilding.

Difficulty: Very Difficult

Time Limit: 5 years

Win Condition: Metropolis

HAMBURG, GERMANY 1944–FIRE

Allied fire-bombing of German cities in WWII caused tremendous devastation and loss of life. People living in the inner cities were at greatest risk. You must control the firestorms during the bombing and then rebuild the city after the war.

Difficulty: Very Difficult

Time Limit: 5 years

Win Condition: Metropolis

BERN, SWITZERLAND 1965–TRAFFIC

The roads here are becoming more congested with automobile traffic every day, and the residents are upset. They demand that you do something about it. Some have suggested a mass transit system as the answer, but this may require major rezoning in the downtown area.

Difficulty: Easy

Time Limit: 10 years

Win Condition: Low Average Traffic Density

TOKYO, JAPAN 1957–MONSTER ATTACK

A large reptilian creature rose from Tokyo Bay and rampaged through the city, destroying much of the industry along the bay.

Difficulty: Moderately Difficult

Time Limit: 5 years

Win Condition: City Score above 500

DETROIT, MI 1972–CRIME

By 1970, competition from overseas and other economic factors pushed the once "automobile capital of the world" into recession. Plummeting land values and unemployment increased crime in the inner-city to chronic levels. You have just been elected after promising to reduce the crime and rebuild the industrial base of the city.

Difficulty: Moderately Difficult

Time Limit: 10 years

Win Condition: Low Average Crime Density

BOSTON, MA 2010–NUCLEAR MELTDOWN

A major meltdown is about to occur at one of the new downtown nuclear reactors. The area in the vicinity of the reactor will be severely contaminated by radiation, forcing you to restructure the city around it.

Difficulty: Very Difficult

Time Limit: 5 years

Win Condition: City Score above 500

RIO de JANEIRO, BRAZIL 2047–FLOOD

In the mid-21st century, the greenhouse effect raised global temperatures 6 degrees F. Polar icecaps melted and raised sea levels worldwide. Coastal areas were devastated by flood and erosion. Unfortunately, some of the largest cities in the world are located on the coasts.

Difficulty: Moderately Difficult

Time Limit: 10 years

Win Condition: City Score above 500

GAME PLAY LEVEL AND GROWING A CITY

When you first start a new city you must pick a difficulty level. Once a city is started you cannot change the game play level; it remains at your initial setting for the life of the city. The game level setting is displayed in the evaluation window.

This level–Easy, Medium, or Hard–adjusts the simulation to your current abilities by altering several factors. A harder setting will increase the chance of disasters, make residents more intolerant of taxation, cause maintenance costs to grow, etc.

While growing a city, refer often to the chart of City Dynamics. It shows how all factors of city life and growth are related.

The main points to keep in mind while growing a city are:

Grow slowly. Watch your money.

All zones must be powered to develop.

Zones must be developed to generate tax money.

Roads or rails must provide access to and from each zone for it to fully develop.

There is a yearly maintenance cost for each section of road, rail, bridge and tunnel. This can add up. Don't build too many roads and rails and generate high maintenance costs before your city can generate enough tax revenues to support them.

Extra power plants and redundant power lines are expensive, but can keep zones from losing power during a disaster or emergency and deteriorating.

Rails can carry much more traffic than roads. While building and zoning an area that you predict will generate heavy traffic, install rails instead of roads in the early stages of development.

If you get a lot of heavy traffic warnings, replace roads with rails. You can even build an entirely roadless city.

Grouping zones together, four or five in a row touching each other, can eliminate a lot of power line segments.

Airports, seaports and stadiums won't help a small city grow-so save your money until the city gets larger. The Sims will tell you when they need these things.

Place zones, roads, etc. carefully–they cannot be moved, and you will have to pay to bulldoze them and rebuild.

As a rule of thumb, the number of residential zones should be approximately equal to the sum of commercial and industrial zones. When your city is small, you will need more industrial zones than commercial, and when your city gets larger, you will need more commercial zones than industrial.

Separate the residential areas from the industrial areas.

Proximity to forest, parks, and water increases land value, which increases the taxes collected. Don't bulldoze any more forest than you must. Natural shoreline increases property values more than landfill shoreline.

Keep in mind that proximity to downtown raises property values. The simulator defines the downtown area as "the center of mass of the population density." It calculates the average geographical center of the population.

A bigger, more populous city is not necessarily better. Having a self-supporting, profitable city with pleasant

surroundings is better than a huge city that is always broke and has no forest or shoreline.

Use the various maps and graphs to plan city growth, locate problems, and track your progress. Look for areas that need police and fire coverage as you go, so you don't have to go back and bulldoze developed zones to make room for police and fire stations.

Save your city to disk before trying any major new policy so you can go back if your plan doesn't work.

Print out your city in different stages of evolution to track and plan growth.

Check the Evaluation Window often. The Sims will let you know how you are doing. Also the statistics can be useful; if your population is shrinking, don't go zoning new areas that may never develop, look for problems in the existing zoned areas, and spend your time and money solving them.

SAVE YOUR CITY OFTEN!!!

Note: There is only one animated train car at a time in SimCity. It will not necessarily cover every section of track. This does not mean that the tracks are not working. Don't worry, everything is OK.

Use this chart along with the Query function to identify and investigate individual zones.

CITY DYNAMICS CHART

The City Dynamics Chart lists the factors of city life and growth and shows how they interrelate. Use this chart to guide you in designing your city. It will help you find solutions to the Sims' complaints, and to problems you discover from the maps and graphs.

Inside SimCity

HOW THE SIMULATOR WORKS AND STRATEGIES FOR USING IT

Many factors influence the chance of your city's prospering or floundering: both internal factors (the structure and efficiency of your city) and external factors (the regional economy, disasters, etc.).

ZONES

Your city is divided into three primary zones: residential, commercial and industrial. These zones symbolize the three basic pillars upon which a city is based: population, industry, and commerce. All three are necessary for your city to grow and thrive.

RESIDENTIAL ZONES are where the Sims live. Here they build houses, apartments and community facilities such as churches and schools. Sims are the work force for your city's commercial and industrial zones.

INDUSTRIAL ZONES are used to site warehouses, factories, and other unsightly and polluting structures which have a negative impact on surrounding zones. One of the major goals of planning is to separate these "nuisances" from the areas where people live. In this simulation, industrial zones represent the "basic" production of your city. Things

produced here are sold outside the city to an "external market," bringing money into the city for future growth.

COMMERCIAL ZONES represent the retail stores and services in your city, including gas stations, grocery stores, banks, and offices. Commercial areas are mainly dedicated to producing goods and services needed within your city. This is called "non-basic" production or production for the "internal market."

POPULATION - RESIDENTIAL

The major factors controlling residential population are birthrate, availability of jobs and housing, unemployment, and quality of life within the city.

Birthrate as used here, is actually a combination of the birthrate (+) and the deathrate (-). Within SimCity there is always a positive birthrate.

Availability of jobs (the employment rate) is a ratio of the current commercial and industrial populations to the total residential population. As a rule of thumb, the number of commercial and industrial zones together should roughly equal the number of residential zones.

If there are more jobs in your city than residents, new settlers will be attracted. If the job market declines during a local recession, your people will migrate away in search of jobs.

Housing for your residents is built in the residential zones. These zones must be powered and connected to the places of employment by roads. The structures built in residential zones are influenced by land value and population density.

Quality of life is a measure of relative "attractiveness" assigned to different zone locations. It is affected by negative

factors such as pollution and crime, and positive factors such as parks and accessibility.

EXTERNAL MARKET–INDUSTRIAL

Thousands of variables influence your city. You can influence all these variables by your actions, except for of one.

The external market (the economic conditions that exist outside of your city) is controlled by the simulation–there is nothing you can do to change it. In many ways, this external market is the original source of all city growth. Towns frequently begin as production centers (steel towns, refineries, etc.) that service a demand in the surrounding region. As time passes, the external market grows to reflect the regional growth going on around your city.

The industry in your city will attempt to grow as the external market grows. For this to happen there must be room for expansion (more industrial zones) and an adequate labor supply (more residential zones).

INTERNAL MARKET–COMMERCIAL

The internal market is completely influenced by the conditions within your city. Internal production, created in the commercial zones, represents all the things purchased and consumed within the city. Food stores, gas stations, retail stores, financial services, medical care, etc.– all depend on a nearby population to service. Within SimCity, the size of the internal market determines the rate at which commercial zones will prosper. Commercial zones need enough zoned land to build on and an existent, sufficient work force to employ. The structures built in commercial zones are mainly influenced by land value and population density.

Commercial zones grow and develop to serve the expanding

internal market. Commercial growth will usually be slow at first, when the population is small and needs very little. As your city grows, commercial growth will accelerate and the internal market will become a much larger consumer of your total city production. This accelerating effect, when the external/industrial production is overtaken by the accelerating internal/commercial sector, can turn a sleepy little town of 50,000 into a thriving capital of 200,000 in a few short years.

TAX RATE

The tax rate you set controls the amount of income generated by your city. As taxes are collected each year (simulation time), the Budget Window will appear, giving you the fiscal details of your city and a chance to adjust rates. The simulation determines the amount of revenue collected by assessing each zone an amount based on its land value, current level of development and the current tax rate.

The tax rate has a global affect on your city's growth rate. If you set it low (0–4%), growth will be brisk but the city income will be low. If you set it high (10–20%), you will collect a lot in the short run but in the long run tax income will decrease along with the population. You must keep tax income high enough to invest in new development, but low enough not to scare off residents and businesses. A high tax rate is one way to control city growth, should you want to experiment with "growth control measures."

BUDGETING

City budgeting affects the way your city grows. City infrastructure cost is represented by three departments: police, fire, and transportation. You may set the funding levels separately for each. All three departments will request a certain level of funding each year. You may supply all or part of the requested funds, in the attempt to balance safety

needs and budgetary concerns.

POLICE DEPARTMENTS

Police stations lower the crime rate within a territory. The effective radius of your police station is related to the amount of funding allocated to the police department.

FIRE DEPARTMENTS

Fire departments prevent and extinguish fires. The level of funding determines the effective radius of a fire department. Fire departments put out fires within this radius much sooner than outside it, and decrease the chance that they will start in the first place. Fire departments cost $100 per year to fund.

TRANSPORTATION DEPARTMENT

When you build roads and rail systems you are charged for construction and yearly maintenance. The larger your transportation network, the more it will cost for upkeep. If you decide not to or are unable to pay this maintenance cost, roads will slowly deteriorate and become unusable. The maintenance cost for each piece is: Road - $1, Bridge - $4, Rail - $4, Rail tunnel - $10.

POWER

Electrical power makes modern cities possible. Efficient and reliable power transmission to all zones is the goal of good "power management."

The entire power grid of your city is periodically checked in the simulation for links to power. If a zone is connected (by other zones or power lines) to a power plant, the zone is considered powered.

Zones must be powered for development to occur. Many

things (such as fires, tornadoes, earthquakes and bulldozers) can knock down power lines and cause blackouts in parts of your city. Development will stop in unpowered zones, and if power is not quickly restored, the zone will decline back to its original state of emptiness.

Redundant Power Plants and power connections can make your power grid more reliable, but running more line adds construction costs.

TRANSPORTATION–TRAFFIC

One of the most important elements of city structure is the transportation network. It moves Sims and goods throughout your city. Roads typically occupy as much as 25%–40% of the land in urban areas. Traffic along these roads indicates which sections of your road system are used the most.

Traffic levels are simulated by a process known as "Trip Generation." Over time, each populated zone in the city will generate a number of trips, depending on the population. Each generated trip starts at the origin zone, travels down the road, and if a "proper destination" is reached, ends at the destination zone–otherwise, the trip fails. Trip failure indicates inaccessibility of a zone and limits its growth.

The majority of generated trips represent people commuting to and from work. Additional traffic is generated by residents traveling to shopping, recreation, etc. When analyzing traffic, the simulator tests the following traffic routes:

From: ORIGIN ZONE	To: DESTINATION ZONE
Residential	Commercial zones and Industrial
Commercial	Residential zones and Industrial
Industrial	Residential

When Sims drive away from an origin zone, they have a limited "trip range" in which to find a destination zone. Heavy traffic decreases the trip range. If the destination zone is too far away, the trip is unsuccessful. Repeated unsuccessful trips will cause the Sims to move out of the origin zone.

Each road has a limited capacity for traffic. When this capacity is exceeded traffic jams will form. Traffic jams drastically lower the capacity of a road, compounding the problem and frustrating drivers.

Traffic conditions fluctuate quickly. Avoid traffic problems by providing several routes for the traffic to take.

A road must be adjacent to a zone for the zone to be connected to the traffic pattern. Zones do not conduct traffic the way they conduct power.

POLLUTION

Pollution levels are tracked in all areas of your city. This is a general "nuisance level" that includes air and water pollution, noise pollution, toxic wastes, etc. Pollution has a negative impact on the growth of residential areas.

The primary cause of pollution is industrialized zones. The level of pollution created by an industrial zone increases with its level of growth.

Traffic is another cause of pollution. There are limited means of combating the pollution level. Lowering traffic density, limiting industrial development, and separating the pollution from the residential areas will help.

CRIME

Crime rates are influenced by population density, local law enforcement, and land values. As population density increases in an area, the number of crimes committed increases. Crime will also increase in areas of low land value.

The most effective way to deal with high crime rates is to introduce a police station into the area. Based on its level of funding, the police station will reduce the rate of crime in its sphere of influence. A long-term approach to lowering crime is to raise the land value of the area. One way to do this is to demolish and rezone (urban renewal).

LAND VALUE

Land value is one of the most fundamental aspects of urban structure. The land value of an area affects how that area is used. In this simulation the land value of an area is based on terrain, accessibility, pollution, and distance to downtown.

The farther the residents have to go to work, the lower the land value where they live, due in part to transportation costs. The value of commercial zones depends greatly on accessibility by the populace.

Land value is also affected by surrounding terrain. If land is closer to water, trees, agricultural areas, or parks, its value will rise. Creative placement of zones within the terrain, with little bulldozing, can make good use of this natural advantage.

HISTORY OF CITIES AND CITY PLANNING

by Cliff Ellis

Introduction

The building of cities has a long and complex history. Although city planning as an organized profession has existed for less than a century, all cities display various degrees of forethought and conscious design in their layout and functioning.

Early humans led a nomadic existence, relying on hunting and gathering for sustenance. Between 8,000 and 10,000 years ago, systematic cultivation of plants and the domestication of animals allowed for more permanent settlements. During the fourth millennium BC, the requirements for the "urban revolution" were finally met: the production of a surplus of storable food, a system of writing, a more complex social organization, and technological advances such as the plough, potter's wheel, loom, and metallurgy.

Cities exist for many reasons, and the diversity of urban forms can be traced to the complex functions that cities perform. Cities serve as centers of storage, trade, and manufacture. The agricultural surplus from the surrounding countryside is processed and distributed in cities. Cities also grew up around marketplaces, where goods from distant places could be exchanged for local products. Throughout history, cities have been founded at the intersections of transportation routes, or at points where goods must shift from one mode of transportation to another, as at river and ocean ports.

Religious elements have been crucial throughout urban history. Ancient peoples had sacred places, often associated with cemeteries or shrines, around which cities grew. Ancient cities usually had large temple precincts with monumental religious buildings. Many medieval cities were built near monasteries and cathedrals.

Cities often provided protection in a precarious world. During attacks, the rural populace could flee behind city walls, where defense forces assembled to repel the enemy. The wall served this purpose for millennia, until the invention of heavy artillery rendered walls useless in warfare. With the advent of modern aerial warfare, cities have become prime targets for destruction rather than safe havens.

Cities serve as centers of government. In particular, the emergence of the great nation-states of Europe between 1400 and 1800 led to the creation of new capital cities or the investing of existing cities with expanded governmental functions.

Washington, DC, for example, displays the monumental buildings, radial street pattern, and large public spaces typical of capital cities.

Cities, with their concentration of talent, mixture of peoples, and economic surplus, have provided a fertile ground for the evolution of human culture: the arts, scientific research, and technical innovation. They serve as centers of communication, where new ideas and information are spread to the surrounding territory and to foreign lands.

Constraints on City Form

Cities are physical artifacts inserted into a preexisting natural world, and natural constraints must be respected if a settlement is to survive and prosper. Cities must conform to

the landscape in which they are located, although technologies have gradually been developed to reorganize the land to suit human purposes. Moderately sloping land provides the best urban site, but spectacular effects have been achieved on hilly sites such as San Francisco, Rio de Janeiro, and Athens.

Climate influences city form. For example, streets have been aligned to take advantage of cooling breezes, and arcades designed to shield pedestrians from sun and rain. The architecture of individual buildings often reflects adaptations to temperature, rainfall, snow, wind and other climatic characteristics.

Cities must have a healthy water supply, and locations along rivers and streams, or near underground watercourses, have always been favored. Many large modern cities have outgrown their local water supplies and rely upon distant water sources diverted by elaborate systems of pipes and canals.

City location and internal structure have been profoundly influenced by natural transportation routes. Cities have often been sited near natural harbors, on navigable rivers, or along land routes determined by regional topography.

Finally, cities have had to survive periodic natural disasters such as earthquakes, hurricanes, tornadoes, and floods. The San Francisco earthquake of 1906 demonstrated how natural forces can undo decades of human labor in a very short time.

Elements of Urban Structure

City planners must weave a complex, ever-changing array of elements into a working whole: that is the perennial challenge of city planning. The physical elements of the city can be divided into three categories: networks, buildings, and open spaces. Many alternative arrangements of these

components have been tried throughout history, but no ideal city form has ever been agreed upon. Lively debates about the best way to arrange urban anatomies continue to rage, and show no signs of abating.

NETWORKS

Every modern city contains an amazing array of pathways to carry flows of people, goods, water, energy, and information. Transportation networks are the largest and most visible of these. Ancient cities relied on streets, most of them quite narrow by modern standards, to carry foot traffic and carts. The modern city contains a complex hierarchy of transportation channels, ranging from ten-lane freeways to sidewalks. In the United States, the bulk of trips are carried by the private automobile, with mass transit a distant second. American cities display the low-density sprawl characteristic of auto-centered urban development. In contrast, many European cities have the high densities necessary to support rail transit systems.

Modern cities rely on complex networks of utilities. When cities were small, obtaining pure water and disposing of wastes was not a major problem, but cities with large populations and high densities require expensive public infrastructure. During the nineteenth century, rapid urban growth and industrialization caused overcrowding, pollution, and disease in urban areas. After the connection between impure water and disease was established, American and European cities began to install adequate sewer and water systems. Since the late nineteenth century, cities have also been laced with wires and conduits carrying electricity, gas, and communications signals.

BUILDINGS

Buildings are the most visible elements of the city, the features that give each city its unique character. Residential

structures occupy almost half of all urban land, with the building types ranging from scattered single-family homes to dense high-rise apartments. Commercial buildings are clustered downtown and at various subcenters, with skyscrapers packed into the central business district and low-rise structures prevailing elsewhere, although tall buildings are becoming more common in the suburbs. Industrial buildings come in many forms ranging from large factory complexes in industrial districts to small workshops.

City planners engage in a constant search for the proper arrangement of these different types of land use, paying particular attention to the compatibility of different activities, population densities, traffic generation, economic efficiency, social relationships, and the height and bulk of buildings.

OPEN SPACES

Open space is sometimes treated as a leftover, but it contributes greatly to the quality of urban life. "Hard" spaces such as plazas, malls, and courtyards provide settings for public activities of all kinds. "Soft" spaces such as parks, gardens, lawns, and nature preserves provide essential relief from harsh urban conditions and serve as space for recreational activities. These "amenities" increasingly influence which cities will be perceived as desirable places to live.

Evolution of Urban Form

The first true urban settlements appeared around 3,000 BC in ancient Mesopotamia, Egypt, and the Indus Valley. Ancient cities displayed both "organic" and "planned" types of urban form. These societies had elaborate religious, political, and military hierarchies. Precincts devoted to the activities of the elite were often highly planned and regular in form. In contrast, residential areas often grew by a slow process of

accretion, producing the complex, irregular patterns that we term "organic." Two typical features of the ancient city are the wall and the citadel: the wall for defense in regions periodically swept by conquering armies, and the citadel-a large, elevated precinct within the city-devoted to religious and state functions.

Greek cities did not follow a single pattern. Cities growing slowly from old villages often had an irregular, organic form, adapting gradually to the accidents of topography and history. Colonial cities, however, were planned prior to settlement using the grid system. The grid is easy to lay out, easy to comprehend, and divides urban land into uniform rectangular lots suitable for development.

The Romans engaged in extensive city-building activities as they consolidated their empire. Rome itself displayed the informal complexity created by centuries of organic growth, although particular temples and public districts were highly planned. In contrast, the Roman military and colonial towns were laid out in a variation of the grid. Many European cities, including London and Paris, sprang from these Roman origins.

We usually associate medieval cities with narrow winding streets converging on a market square with a cathedral and city hall. Many cities of this period display this pattern, the product of thousands of incremental additions to the urban fabric. However, new towns seeded throughout undeveloped regions of Europe were based upon the familiar grid. In either case, large encircling walls were built for defense against marauding armies; new walls enclosing more land were built as the city expanded and outgrew its former container.

During the Renaissance, architects began to systematically study the shaping of urban space, as though the city itself were a piece of architecture that could be given an

aesthetically pleasing and functional order. Many of the great public spaces of Rome and other Italian cities date from this era. Parts of old cities were rebuilt to create elegant squares, long street vistas, and symmetrical building arrangements. Responding to advances in firearms during the fifteenth century, new city walls were designed with large earthworks to deflect artillery, and star-shaped points to provide defenders with sweeping lines of fire. Spanish colonial cities in the New World were built according to rules codified in the Laws of the Indies of 1573, specifying an orderly grid of streets with a central plaza, defensive wall, and uniform building style.

We associate the baroque city with the emergence of great nation-states between 1600 and 1750. Ambitious monarchs constructed new palaces, courts, and bureaucratic offices. The grand scale was sought in urban public spaces: long avenues, radial street networks, monumental squares, geometric parks and gardens. Versailles is a clear expression of this city-building model; Washington, DC is an example from the United States. Baroque principles of urban design were used by Baron Haussmann in his celebrated restructuring of Paris between 1853 and 1870. Haussmann carved broad new thoroughfares through the tangled web of old Parisian streets, linking major subcenters of the city with one another in a pattern that has served as a model for many other modernization plans.

Toward the latter half of the eighteenth century, particularly in America, the city as a setting for commerce assumed primacy. The buildings of the bourgeoisie expanded along with their owners' prosperity: banks, office buildings, warehouses, hotels, and small factories. New towns founded during this period were conceived as commercial enterprises, and the neutral grid was the most effective means to divide land up into parcels for sale. The city became a checkerboard on which players speculated on

shifting land values. No longer would religious, political, and cultural imperatives shape urban development; rather, the market would be allowed to determine the pattern of urban growth. New York, Philadelphia, and Boston around 1820 exemplify the commercial city of this era, with their bustling, mixed-use waterfront districts.

Transition to the Industrial City

Cities have changed more since the Industrial Revolution than in all the previous centuries of their existence. New York had a population of about 313,000 in 1840 but had reached 4,767,000 in 1910. Chicago exploded from 4,000 to 2,185,000 during the same period. Millions of rural dwellers no longer needed on farms flocked to the cities, where new factories churned out products for new markets made accessible by railroads and steamships. In the United States, millions of immigrants from Europe swelled the urban populations. Increasingly, urban economies were being woven more tightly into the national and international economies.

Technological innovations poured forth, many with profound impacts on urban form. Railroad tracks were driven into the heart of the city. Internal rail transportation systems greatly expanded the radius of urban settlement: horsecars beginning in the 1830s, cable cars in the 1870s, and electric trolleys in the 1880s. In the 1880s, the first central power plants began providing electrical power to urban areas. The rapid communication provided by the telegraph and the telephone allowed formerly concentrated urban activities to disperse across a wider field.

The industrial city still focused on the city center, which contained both the central business district, defined by large office buildings, and substantial numbers of factory and warehouse structures. Both trolleys and railroad systems converged on the center of the city, which boasted the

premier entertainment and shopping establishments. The working class lived in crowded districts close to the city center, near their places of employment.

Early American factories were located outside of major cities along rivers that provided water power for machinery. After steam power became widely available in the 1830s, factories could be located within the city in proximity to port facilities, rail lines, and the urban labor force. Large manufacturing zones emerged within the major northeastern and midwestern cities such as Pittsburgh, Detroit, and Cleveland. But by the late nineteenth century, factory decentralization had already begun, as manufacturers sought larger parcels of land away from the congestion of the city. Gary, Indiana, for example, was founded in 1906 on the southern shore of Lake Michigan by the United States Steel Company.

The increasing crowding, pollution, and disease in the central city produced a growing desire to escape to a healthier environment in the suburbs. The upper classes had always been able to retreat to homes in the countryside. Beginning in the 1830s, commuter railroads enabled the upper middle class to commute in to the city center. Horsecar lines were built in many cities between the 1830s and 1880s, allowing the middle class to move out from the central cities into more spacious suburbs. Finally, during the 1890s electric trolleys and elevated rapid transit lines proliferated, providing cheap urban transportation for the majority of the population.

The central business district of the city underwent a radical transformation with the development of the skyscraper between 1870 and 1900. These tall buildings were not technically feasible until the invention of the elevator and steel-frame construction methods. Skyscrapers reflect the dynamics of the real estate market; the tall building extracts

the maximum economic value from a limited parcel of land. These office buildings housed the growing numbers of white-collar employees in banking, finance, management, and business services, all manifestations of the shift from an economy of small firms to one of large corporations.

THE FORM OF THE MODERN CITY IN THE AGE OF THE AUTOMOBILE

The city of today may be divided into two parts: (1) an inner zone, coextensive with the boundaries of the old industrial city, and (2) suburban areas, dating from the 1920s, which have been designed for the automobile from the beginning.

The central business districts of American cities have become centers of information processing, finance, and administration rather than manufacturing. White-collar employees in these economic sectors commute in from the suburbs on a network of urban freeways built during the 1950s and 1960s; this "hub-and-wheel" freeway pattern can be observed on many city maps. New bridges have spanned rivers and bays, as in New York and San Francisco, linking together formerly separate cities into vast urbanized regions.

Waves of demolition and rebuilding have produced "Manhattanized" downtowns across the land. During the 1950s and 1960s, urban renewal programs cleared away large areas of the old city, releasing the land for new office buildings, convention centers, hotels, and sports complexes. Building surges have converted the downtowns of American cities into forests of tall office buildings. More recently, office functions not requiring a downtown location have been moved to huge office parks in the suburbs.

Surrounding the central business area lies a large band of old mixed-use and residential buildings that house the urban poor. High crime, low income, deteriorating services, inadequate housing, and intractable social problems plague

these neglected areas of urban America. The manufacturing jobs formerly available to inner-city residents are no longer there, and resources have not been committed to replace them.

These inner-city areas have been left behind by a massive migration to the suburbs that began in the late nineteenth century but accelerated in the 1920s with the spread of the automobile. Freeway building after World War II opened up even larger areas of suburban land, which were quickly filled by people fleeing central city decline. Today, more people live in suburbs than in cities proper. Manufacturers have also moved their production facilities to suburban locations that have freeway and rail accessibility.

Indeed, we have reached a new stage of urbanization beyond the metropolis. Most major cities are no longer focused exclusively on the traditional downtown. New subcenters have arisen round the periphery, and these subcenters supply most of the daily needs of their adjacent populations. The old metropolis has become a multi-centered urban region. In turn, many of these urban regions have expanded to the point where they have coalesced into vast belts of urbanization-what the geographer Jean Gottman termed "megalopolis." The prime example is the eastern seaboard of the United States from Boston to Washington. The planner C.A. Doxiadis has speculated that similar vast corridors of urbanization will appear throughout the world during the next century. Thus far, American planners have not had much success in imposing a rational form on this process. However, New Town and greenbelt programs in Britain and the Scandinavian countries have, to some extent, prevented formless sprawl from engulfing the countryside.

THE ECONOMICS OF URBAN AREAS

Since the 1950s, city planners have increasingly paid attention to the economics of urban areas. When many

American cities experienced fiscal crises during the 1970s, urban financial management assumed even greater importance. Today, planners routinely assess the economic consequences of all major changes in the form of the city.

Several basic concepts underlie urban and regional economic analysis. First, cities cannot grow if their residents simply provide services for one another. The city must create products that can be sold to an external purchaser, bringing in money that can be reinvested in new production facilities and raw materials. This "economic base" of production for external markets is crucial. Without it, the economic engine of the city grinds to a halt.

Once the economic base is established, an elaborate internal market can evolve. This market includes the production of goods and services for businesses and residents within the city. Obviously, a large part of the city's physical plant is devoted to facilities for these internal transactions: retail stores of all kinds, restaurants, local professional services, and so on.

Modern cities are increasingly engaged in a competition for economic resources such as industrial plants, corporate headquarters, high-technology firms, and government facilities. Cities try to lure investment with an array of features: low tax rates, improved transportation and utility infrastructure, cheap land, and a skilled labor force. Amenities such as climate, proximity to recreation, parks, elegant architecture, and cultural activities influence the location decisions of businesses and individuals. Many older cities have had difficulty surviving in this new economic game. Abandoned by traditional industries, they are now trying to create a new economic base involving growth sectors such as high technology.

Today, cities no longer compete in mere regional or national markets: the market is an international one. Multinational

firms close plants in Chicago or Detroit and build replacements in Asia or Latin America. Foreign products dominate whole sectors of the American consumer goods market. Huge sums of money shift around the globe in instantaneous electronic transactions. Cities must struggle for survival in a volatile environment in which the rules are always changing. This makes city planning even more challenging than before.

Modern City Planning

Modern city planning can be divided into two distinct but related types of planning. Visionary city planning proposes radical changes in the form of the city, often in conjunction with sweeping changes in the social and economic order. Institutionalized city planning is lodged within the existing structures of government, and modifies urban growth processes in moderate, pragmatic ways. It is constrained by the prevailing alignment of political and economic forces within the city.

VISIONARY OR UTOPIAN CITY PLANNING

People have imagined ideal cities for millennia. Plato's Republic was an ideal city, although lacking in the spatial detail of later schemes. Renaissance architects designed numerous geometric cities, and ever since architects have been the chief source of imaginative urban proposals. In the twentieth century, Le Corbusier, Frank Lloyd Wright, Paolo Soleri, and dozens of other architects have designed cities on paper. Although few have been realized in pure form, they have influenced the layout of many new towns and urban redevelopment projects.

In his "Contemporary City for Three Million People" of 1922 and "Radiant City" of 1935, Le Corbusier advocated a high-density urban alternative, with skyscraper office buildings and mid-rise apartments placed within park-like open spaces.

Different land uses were located in separate districts, forming a rigid geometric pattern with a sophisticated system of superhighways and rail transit.

Frank Lloyd Wright envisioned a decentralized low-density city in keeping with his distaste for large cities and belief in frontier individualism. The Broadacre City plan of 1935 is a large grid of arterials spread across the countryside, with most of the internal space devoted to single-family homes on large lots. Areas are also carefully set aside for small farms, light industry, orchards, recreation areas, and other urban facilities. A network of superhighways knits the region together, so spatially dispersed facilities are actually very close in terms of travel time. In many ways, Wright's Broadacre City resembles American suburban and exurban developments of the post-WWII period.

Many other utopian plans could be catalogued, but the point is that planners and architects have generated a complex array of urban patterns from which to draw ideas and inspiration. Most city planners, however, do not work on a blank canvas; they can only make incremental changes to an urban scene already shaped by a complicated historical process.

INSTITUTIONALIZED CITY PLANNING

The form of the city is determined primarily by thousands of private decisions to construct buildings, within a framework of public infrastructure and regulations administered by city, state, and federal governments. City planning actions can have enormous impacts on land values. From the point of view of land economics, the city is an enormous playing field on which thousands of competitors struggle to capture value by constructing or trading land and buildings. The goal of city planning is to intervene in this game in order to protect widely shared public values such as health, safety, environmental quality, social equity, and aesthetics.

The roots of American city planning lie in an array of reform efforts of the late nineteenth century: the Parks movement, the City Beautiful movement, campaigns for housing regulations, the Progressive movement for government reform, and efforts to improve public health through the provision of sanitary sewers and clean water supplies. The First National Conference on City Planning occurred in 1909, the same year as Daniel Burnham's famous Plan of Chicago. That date may be used to mark the inauguration of the new profession. The early city planners actually came from diverse backgrounds such as landscape architecture, architecture, engineering, and law, but they shared a common desire to produce a more orderly urban pattern.

The zoning of land became, and still is, the most potent instrument available to American city planners for controlling urban development. Zoning is basically the dividing of the city into discrete areas within which only certain land uses and types of buildings can be constructed. The rationale is that certain activities or building types don't mix well; factories and homes, for example. Illogical mixtures create nuisances for the parties involved and lower land values. After several decades of gradual development, land-use zoning received legal approval from the Supreme Court in 1926.

Zoning isn't the same as planning: it is a legal tool for the implementation of plans. Zoning should be closely integrated with a Master Plan or Comprehensive Plan that spells out a logical path for the city's future in areas such as land use, transportation, parks and recreation, environmental quality, and public works construction. In the early days of zoning this was often neglected, but this lack of coordination between zoning and planning is less common now.

Two other important elements of existing city planning are subdivision regulations and environmental regulations.

Subdivision regulations require that land being subdivided for development be provided with adequate streets, sewers, water, schools, utilities, and various design features. The goal is to prevent shabby, deficient developments that produce headaches for both their residents and the city. Since the late 1960s, environmental regulations have exerted a stronger influence on patterns of urban growth by restricting development in floodplains, on unstable slopes, on earthquake faults, or near sensitive natural areas. Businesses have been forced to reduce smoke emissions and the disposal of wastes has been more closely monitored. Overall, the pace of environmental degradation has been slowed, but certainly not stopped, and a dismaying backlog of environmental hazards remains to be cleaned up. City planners have plenty of work to do as we move into the twenty-first century.

Conclusion: Good City Form

What is the good city? We are unlikely to arrive at an unequivocal answer; the diversity of human needs and tastes frustrates all attempts to provide recipes or instruction manuals for the building of cities. However, we can identify the crucial dimensions of city performance, and specify the many ways in which cities can achieve success along these dimensions.

A most useful guide in this enterprise is Kevin Lynch's A Theory of Good City Form (Cambridge, MA, MIT Press, 1981). Lynch offers five basic dimensions of city performance: vitality, sense, fit, access, and control. To these he adds two "meta-criteria," efficiency and justice.

For Lynch, a vital city successfully fulfills the biological needs of its inhabitants, and provides a safe environment for their activities. A sensible city is organized so that its residents can perceive and understand the city's form and function. A city with good fit provides the buildings, spaces,

and networks required for its residents to pursue their projects successfully. An accessible city allows people of all ages and backgrounds to gain the activities, resources, services, and information that they need. A city with good control is arranged so that its citizens have a say in the management of the spaces in which they work and reside.

Finally, an efficient city achieves the goals listed above at the least cost, and balances the achievement of each goal with all the others. They cannot all be maximized at the same time. And a just city distributes benefits among its citizens according to some fair standard. Clearly, these two meta-criteria raise difficult issues which will continue to spark debates for the foreseeable future.

These criteria tell aspiring city builders where to aim, while acknowledging the diverse ways of achieving good city form. Cities are endlessly fascinating because each is unique, the product of decades, centuries, or even millennia of historical evolution. As we walk through city streets, we walk through time, encountering the city-building legacy of past generations. Paris, Venice, Rome, New York, Chicago, San Francisco-each has its glories and its failures. In theory, we should be able to learn the lessons of history and build cities that our descendants will admire and wish to preserve. That remains a constant challenge for all who undertake the task of city planning.

BIBLIOGRAPHY

Boyer, R., and D. Savageau. Places Rated Almanac. Chicago: Rand McNally & Co., 1986.

Callenbach, Ernest. Ecotopia. Berkeley: Banyan Tree Books, 1975.

Choay, Francoise. The Modern City: Planning in the 19th Century. New York: George Braziller, 1969.

Clark, David. Urban Geography. Baltimore: The Johns Hopkins University Press, 1982.

Clay, Grady. Close-Up, How to Read the American City. Chicago: The University of Chicago Press, 1980.

Gallion, A., and S. Eisner. The Urban Pattern. New York: Van Nostrand Reinhold Company, 1986.

Greenburg, M., D. Krueckeberg, and C. Michaelson. Local Population and Employment Projection Techniques. New Brunswick: Center for Urban Policy Research, 1987.

Hoskin, Frank P. The Language of Cities. Cambridge: Schenkman Publishing Company, Inc., 1972.

Jacobs, Jane. The Death and Life of Great American Cities. New York: Vintage Books, 1961.

Kueckeberg, Donald. Urban Planning Analysis: Methods and Models. New York: John Wiley & Sons, 1974.

Le Corbusier. The City of Tomorrow and Its Planning. New York: Dover Publications, Inc., 1987.

Register, Richard. Ecocity Berkeley. Berkeley: North Atlantic Books, 1987.

Planning (The magazine of the American Planning Association) 1313 E. 60th St. Chicago, IL 60637

Realted Reading for Children

FICTION

Burton, Virginia Lee. The Little House. Boston: Houghton Mifflin, 1942 (reissued 1969).

Murphy, Shirley, and Murphy, Pat. Mrs. Tortino's Return to the Sun. Shepard Books, 1980.

Dr. Seuss. The Lorax. New York: Random House, 1971.

NONFICTION

Barker, Albert. From Settlement to City. New York: Julian Messner, 1978.

Eichner, James A. The First Book of Local Government. New York: Franklin Watts, 1976.

Macaulay, David. City: A Story of Roman Planning and Construction. Boston: Houghton Mifflin, 1974.

Macaulay, David. Underground. Boston: Houghton Mifflin, 1976.

Monroe, Roxie. Architects Make Zigzags: Looking at Architecture from A to Z. Washington D.C.: National Trust for Historic Preservation, 1986.

Rhodes, Dorothy. How to Read a City Map. Chicago: Elk Grove Press, 1967.

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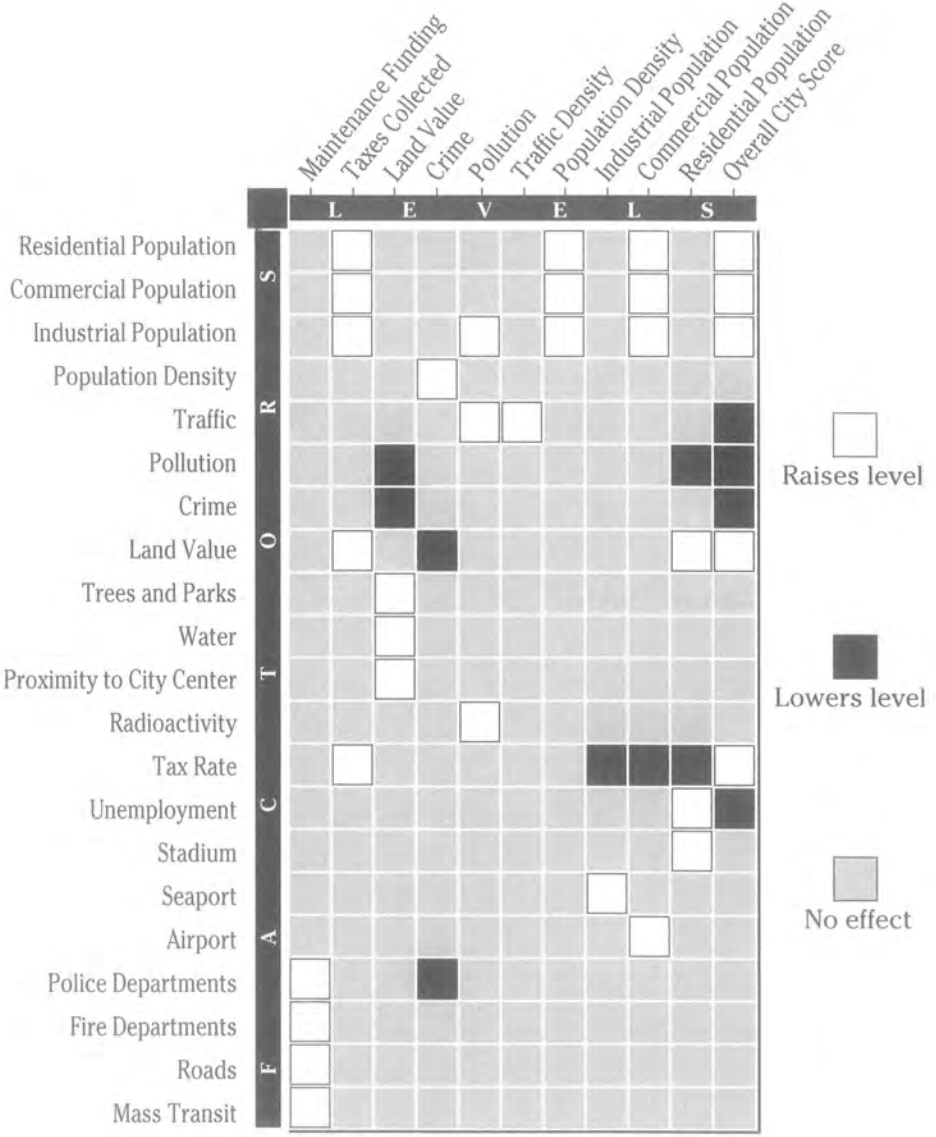
City Dynamics Chart



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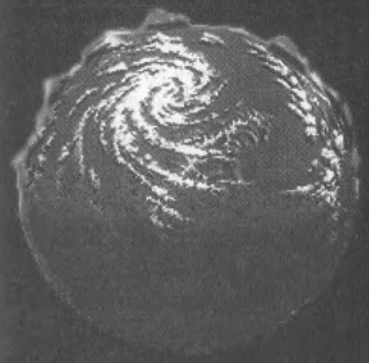

USER MANUAL

by

MICHAEL BREMER

SimEarth Credits

Concept and Design: Will Wright and Fred Haslam

Design Assistance: James Lovelock

Macintosh Programming: Fred Haslam, Will Wright
IBM Programming: Daniel Goldman, Paul Schmidt
Windows Programming: Rodney T. Lai, Paul Schmidt
Computer Graphics: Peter & Caitlin Mitchell-Dayton, Jenny Martin, Suzie Greene
Macintosh Sound and Music: Steve Hales
IBM Sound and Music: Heath Paterson

Package Design: Richard Bagel, Kurt West
Package Illustration: Kurt West
Documentation Design: Richard Bagel, Kurt West, Chris Yoro, Mark Holmes, Michael Bremer

Documentation: Michael Bremer
Introduction to Earth Science: Carolina Lithgow, Tom Bentley
Contributions to Documentation: James Lovelock, Will Wright, Fred Haslam, Tom Bentley, Robin Samelson, Michael Patterson, Bill Cook, Joe Scirica

Product Managers: Steve Beckert, IBM & Mac
Mitzi S. McGilvray, Windows
King of Manufacturing: Dave Helfenstein
Q/A & Tech Support: Bill Cook, Steve Smythe, Alan Barton, Manny J. Granillo, Jake Hoelter, Kevin O'Hare, Michael Patterson, Carter Lipscomb

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Dedicated to Gaia, without whom this game would not be possible.

MAXIS 2121 N. California Blvd.
Walnut Creek, CA 94596-3572

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SimEarth has no disk-based copy protection. You are free to make backup copies for personal use. Defective media returned within ninety days from date of purchase will be replaced without charge. Returning the registration card will extend the warranty.

License

As the original purchaser, you have the right to use SimEarth only on a single computer. You may physically transfer the program from one computer to another provided the program is used only on one computer at any time. You may not distribute copies of SimEarth or accompanying documentation to others.

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INTRODUCTION

"Is this a random world or did you planet?"

The most pondered question by SimEarthling philosophers.

WHAT IS SIMEARTH?

SimEarth is a planet simulator—a model of a planet. It is a game, an educational toy, and an enjoyable tool. With SimEarth you can take over many included planets, or design and create your own.

SimEarth is based on the Gaia theory by James Lovelock, which suggests that we look at our planet and the life on it as a whole, and not as separate areas of study.

SimEarth treats the planet as a whole: life, climate, the atmosphere, and the planet itself—from dirt and rock to the molten core—all affect each other.

You will see your planet as a whole—from a satellite's point of view, at two levels of magnification.

SimEarth can be played in two modes: *game* and *experimental*. In game mode, you will try to develop, manage, and preserve your planet within allotted energy budgets.

In experimental mode, you are given unlimited energy to mold your planet. This allows you to set up any type of planet in any stage of development, and then introduce any new factors you want and see what happens. In this mode SimEarth is a "planetary spreadsheet."

Your SimEarth planets will be populated by electronic life-forms called SimEarthlings—cousins of the Sims who populate SimCity™ (another fine product from Maxis). SimEarthlings range from single-celled plants and animals to intelligent species.

Intelligent SimEarthlings are not limited to Humans—or even Mammals. There can be intelligent Dinosaur SimEarthlings, intelligent Mollusk SimEarthlings, even intelligent Insect SimEarthlings—but only one intelligent life-form at a time.

A single planet can be populated by billions and billions of SimEarthlings. Their welfare is in your hands.

WHAT IS GAIA?

by JAMES LOVELOCK,
the originator of the Gaia theory

Gaia is a theory about the evolution of the Earth. A theory that sees the evolution of the species of organisms by natural selection and the evolution of the rocks, air and oceans as a single tightly coupled process. In Gaia the organisms and their material environment together constitute a system which is able to self-regulate climate and atmospheric composition.

The fact that the Earth's mean temperature has remained constant and favourable for life for 3.6 billion years in spite of a rise in output of heat from the Sun of 25%, and the fact that oxygen has remained close to 21% of our atmosphere for 200 million years, can be explained by Gaia theory but not by conventional science. Although it is a scientific theory, the name Gaia was proposed by the novelist William Golding.

Gaia became visible through the new knowledge about the Earth gained from space and from the extensive investigations of the Earth's surface, oceans and atmosphere during the past few decades. This view has in it something of the poetic metaphor of a ship held by the sailors, but it is also a hard science theory of our planet that came from a top-down view from space. This theory is now up for trial, and the evidence gathered from the Earth itself will decide on whether or not it should be taken as scientific fact. Don't be misled by those who argue that Gaia is untestable or teleological and therefore in error; their criticism is mere opinion based on prejudice, not evidence. Even if in the end Gaia should turn out to be no more than a poetic metaphor, it would still have been worth thinking of the Earth as a living system. Such thoughts have already led to discoveries about the Earth that could not have come from conventional wisdom.

Gaia is a top-down view of the Earth as a single system, and is essentially physiological. It is about the working of the whole system, not with the separated parts of a planet divided arbitrarily into the biosphere, the atmosphere, the lithosphere and the hydrosphere. These are not real divisions of the Earth; they are spheres of influence inhabited by academic scientists.

All I ask is that you concede that there might be something in the Gaia theory, which sees the Earth as a living system, to acknowledge Gaia at least for the purpose of argument. I do not expect you to become converts to a new Earth religion. I do not ask you to suspend your common sense. All that I do ask is that you consider Gaia theory as an alternative to the conventional wisdom of a dead planet made of inanimate rocks, ocean and atmosphere merely inhabited by life. Consider it as a real system, comprising all of life and all of its environment tightly coupled so as to form a self-regulating entity. Maybe you already have it in mind

when you use that vague, ill-defined word "Biosphere" that seems to have a different meaning for each occasion of its use.

I recognise that to view the Earth as if it were alive is just a convenient, but different, way of organising the facts of the Earth. I am of course prejudiced in favor of Gaia and have filled my life for the past 25 years with the thought that Earth may be alive: not as the ancients saw her—a sentient Goddess with a purpose and foresight—but alive like a tree. A tree that quietly exists, never moving except to sway in the wind, yet endlessly conversing with the sunlight and the soil. Using sunlight and water and nutrient minerals to grow and change. But all done so imperceptibly, that to me the old oak tree on the green is the same as it was when I was a child.

SOFTWARE TOYS AND SYSTEM SIMULATIONS

SOFTWARE TOYS

SimEarth isn't exactly a game...it's what we call a "Software Toy." Toys, by definition, are more flexible and open-ended than games.

As an example, compare a game, tennis, with a toy, a ball. In every tennis game, there is one way to begin, one goal to pursue, and one way to end. There are infinite variations in the middle, but they all start the same way, chase the same goal, and end the same way.

A ball is more flexible—there are more things you can do with it. With the ball, you can play tennis. You can play catch. You can throw it at someone. You can bounce it. You can make up a hundred different games using the ball.

Our Software Toys are programmable. Using the comparison with a ball, this means that you can change the tennis ball into a football, baseball, soccer ball, Ping Pong ball, etc., and play any and all the games you play with those balls.

Besides games, there are other things you can do with a ball. You can paint it, use it to plug a leaky roof, or just contemplate its roundness.

In SimEarth, the "toy" is a planet—a programmable planet that can become an infinite number of planets.

So when you play with SimEarth, or any of our Software Toys, don't limit yourself to trying to "win." Play with it. Experiment. Try new things. Just have fun.

SYSTEM SIMULATIONS

There are many types of toys. SimEarth, like SimCity before it, is a SYSTEM SIMULATION toy. In a system simulation, we provide you with a set of RULES and TOOLS that describe, create and control a system. In the case of SimEarth, the system is a planet.

Part of the challenge of playing with a SYSTEM SIMULATION toy is to figure out how the system works and take control of it. As master of the system you are free to use the TOOLS to create and control an unlimited number of systems (in this case, planets) within the framework provided by the RULES.

In SimEarth, the RULES to learn are based on global systems and management, including:

Chemical Factors:	atmospheric composition, energy management
Geological Factors:	climate, extraterrestrial collisions, continental drift, earthquakes
Biological Factors:	formation of life, evolution, food supply, biome types and distribution
Human Factors:	wars, civilization, technology, waste control, pollution, food supply, energy supply

The TOOLS provide you with the ability to create, modify and manage a planet:

- Create a planet in any of four Time Scales.
- Physically modify the landscape of the planet.
- Set the altitude of any spot on the planet.
- Trigger events on the planet from hurricanes to volcanos to meteor strikes.
- Plant various biomes and life-forms anywhere on the planet.
- Nurture a species to help it evolve intelligence.
- Manage your planet by making use of the available maps and graphs.

But the most important TOOL of all is the simulator itself. Test your plans, theories and ideas as you watch your planet develop or decline. Customize the simulation by changing the rules that control the geosphere, the atmosphere, the biosphere, and civilization, to suit yourself or test life's adaptability to various conditions.

SIMULATION LIMITATIONS AND BIASES

SIMULATION LIMITATIONS

Anything as complicated as the Earth or an animal or even a city cannot be completely defined by formulas and equations. Any model of something this complicated cannot be completely accurate—but if you are aware of the inaccuracies, the model can still be useful.

A street map is a model of a city. It isn't a completely accurate representation of every detail of a city, but, within its limitations, it's very useful. Most of us would be lost without one.

As a simulation of a real planetary system, SimEarth is a rough caricature—an extreme simplification. We simulate many different aspects of a planet, including climate, evolution, atmospheric composition, and civilization, all on a personal computer.

A truly accurate simulation for a climate model alone has not yet been realized even on today's most powerful super-computers. We designed this simulation as accurately as we could while maintaining compatibility with personal computers and including a gaming aspect.

A major limitation to this program is how evolution is treated. It closely follows Earth's evolution. With very few exceptions, all the life-forms represented here actually exist or existed on Earth. While allowing many differences in which species succeed or fail—and eventually gain sentience—the path from single-celled life to complex life is roughly the same as on Earth.

Also, whatever species becomes intelligent—Mammal, Dinosaur, Fish, etc.—will develop civilizations, cities and technologies that greatly resemble Human civilizations, cities and technologies.

BIASES

SimEarth is based on the Gaia theory, as proposed by James Lovelock. Gaia theory is controversial, and not an accepted truth in all scientific circles.

For this game, we are also making a few assumptions that are not necessarily true. One of these assumptions is that intelligence is an evolutionary advantage—we might just be flattering ourselves.

SIMULATOR REACTION TIME

The simulator in SimEarth is a very complex piece of modeling software. It is constantly performing many checks, calculations and updates, as well as keeping watch on the mouse and keyboard to respond to your demands.

When you load in a planet, give the simulator a minute or two to compile and update maps and graphs.

When you make adjustments to the MODEL CONTROL PANELS, allow some time for the changes to take effect.

Simulator reaction time is also greatly affected by your computer's clock speed and type of microprocessor.

GOALS OF SIMEARTH

SCENARIOS

Each of the seven included scenario planets is actually a game in itself that can be played at three levels of difficulty or in experimental mode. Each scenario will present you with different challenges in planet management.

TESTING THE GAIA HYPOTHESIS—DAISYWORLD

One of the main tenets of the Gaia hypothesis is that life itself regulates the conditions on Earth that support life, including temperature and atmospheric content.

One of the scenarios, Daisyworld, is a simplified simulation with only eight life-forms: differently shaded daisies. This scenario is based on the original Daisyworld computer model James Lovelock designed to explain the Gaia hypothesis.

Experimenting with the Daisyworld Scenario will give you a visual demonstration of the concept of Gaia and of life on Earth as a self-regulating whole.

A complete description of how and why the Daisyworld model works is found later in this manual, in the "Scenarios" chapter.

TAKING ON THE ROLE OF GAIA

If you play any of the scenarios or random planets at the most difficult level, all Gaian self-regulation will be disabled. You will have to constantly monitor and adjust everything on the planet to keep life in existence.

YOUR OWN PLANETS

Besides the scenarios, you can create an unlimited number of different planets, at various levels of difficulty.

FUN AND CHALLENGE

Running a planet is a real challenge for even an experienced gamer.

OTHER GOALS

Design, modify, manage, and nurture a planet from creation through formation of the oceans, to the appearance of life, through the evolution of life, through the development of intelligence and technology, to the point where your SimEarthlings can reach for the stars.

Set up a planetary situation and just watch what happens.

Choose and help a particular species gain mastery of the planet.

Influence the life to keep it from destroying itself and the planet.

Perhaps the ultimate goal of SimEarth is for you to design, manage and maintain the planet of your dreams. Your ideal planet may be a high-tech society of intelligent humans (or intelligent dinosaurs) or a limited-technology planet where the biosphere is never endangered.

YOUR OWN GOALS

It's your toy—you make the rules. You don't need a goal if you don't want one. Just play.

ABOUT THIS MANUAL

This manual has two functions: to teach you how to use SimEarth and to introduce you to the basics of Earth Science.

The majority of this manual describes the program *SimEarth*: how it works, how to use it, how it deals with life, climate, geology, atmospheric composition, civilization, etc.

The Introduction to Earth Science section of this manual deals with many of the same things as they are in the real world, out of the context of SimEarth.

This manual covers the SimEarth program for all computers. Any machine-specific information for installing, starting, or using SimEarth will be found on the included system card/addendum.

The graphics used in this manual are taken from the Macintosh monochrome and IBM Hercules and MCGA monochrome versions of SimEarth. Depending on your computer and monitor type, the graphics you see on your screen may vary slightly.

ABOUT ENERGY

In SimEarth there are two uses of energy. You, the player, use it to make, mold, modify and manipulate the planet, and civilized SimEarthlings make and use it to carry on their daily lives. A complete explanation of energy and its uses in SimEarth is found in the "Energy" chapter of this manual.

SIMEARTHLING USE OF ENERGY

Intelligent SimEarthlings will produce and use energy. You can control their choice of energy sources and their use of the energy they produce, but you don't have *direct* access to *their* energy for *your* purposes.

YOUR USE OF ENERGY

Depending on the difficulty level of the game, you will have different amounts of energy to affect the planet and the simulation. These amounts are both your starting supply and the maximum you can accumulate at any one time.

If you are in experimental mode, you will have an unlimited supply of energy.

Energy for a game comes from the stores of the planet itself in the form of geothermal, wind, and solar energy, as well as fossil fuels. As you deplete your energy supplies during a game, they will slowly build back up over time as the planet increases its energy from the above sources. This continual tapping of the planet's energies happens automatically.

Once life on your planet becomes intelligent, you will automatically tap some of their energy. You can't just take the energy; a certain amount will be added to your supply along with the energy tapped from the planet itself.

The higher the level of technology on your planet, the more energy you will receive.

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GETTING STARTED

"All the world's a simulation
And all the Sims and SimEarthlings merely players..."

William Simspeare

INSTALLING SIMEARTH

Please refer to the enclosed system card and machine-specific addendum for installation instructions.

GETTING HELP

SimEarth is a fairly complex program, with lots of windows, icons, buttons, options, and control panels. To make your simulating experience easier, there is a lot of help information included in the program.

THE HELP FUNCTION

Any time you want or need help, or aren't sure what something in the program does, ask for help. Whenever you hold down the SHIFT KEY, you are in help mode, and the cursor changes to HELP. Then click on anything anywhere in SimEarth, and you will get a help message.

THE GLOSSARY

There is an on-line glossary that defines many of the words in the SimEarth program.

To access the glossary, open the WINDOWS MENU, and select GLOSSARY.

There is also a Glossary in the Appendix section of this manual.

THE TUTORIALS

There is a tutorial section in this manual. There is also an on-line abbreviated version of the tutorial.

The on-line text-based tutorial is accessed by selecting TUTORIAL from the WINDOWS MENU. You can even keep the TUTORIAL WINDOW open on the screen while playing the game, and refer to it whenever you need.

Depending on your computer, you may or may not be able to have the on-line tutorial open at the same time as other HELP WINDOWS.

STARTING THE PROGRAM

Please refer to the system card or machine-specific addendum for instructions in starting SimEarth.

The first time you start the program, you will see three windows: the TITLE WINDOW, which goes away as soon as you click the mouse, the EDIT WINDOW, which is your main planetary work space, and a HELP WINDOW, which will tell you how to get started and how to get more help.

Whenever you start SimEarth, there will be no active planet. You will have to select either NEW PLANET or LOAD PLANET from the FILE MENU before the simulation will really start. This is to give you a chance to look around, play with the various windows and controls, and prepare yourself before things start to happen.

The following Tutorial section will guide you through the basics of planet creation and manipulation.

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TUTORIAL

"Fools make a mock at Sim."

SimProverbs xiv. 9.

INTRODUCTION

The purpose of this tutorial is to give you a quick tour of SimEarth's menus, windows, and planet manipulation tools. It won't give every detail of every item in the program. For in-depth explanations of everything in the program see the Reference section of this manual.

BASIC CONCEPTS

Before beginning the tutorial, here are a few basic concepts and terms to get you started.

GAIA THEORY

SimEarth is based on the Gaia theory. Everything in the program is interrelated: climate, animals, plants, and the planet itself all affect each other.

A brief explanation of the Gaia theory is given in the Introduction in the chapter "What is Gaia?" A demonstration of how Gaia works is found in the Daisyworld section of the "Scenarios" chapter.

PLANET

The term "planet" refers to the present planet, world, or scenario that is loaded into memory and is being simulated.

You will view your planet from a satellite's point of view at two different magnifications, and as either a flat robinson projection or a globe.

SIMULATION/SIMULATOR

In SimEarth and this manual, we use the terms "simulation" and "simulator" to represent the part of the program that is modelling the planet. When you change or modify the simulation, you are changing variables and parameters in the model, which in turn change the planet.

The ability to modify the simulation is a powerful tool both for the gaming aspect and the experimental "planetary spreadsheet" aspect of SimEarth.

INPUT AND OUTPUT

SimEarth is a very complicated program. An important part of understanding it is knowing where you can INPUT (change the planet or simulation), and where you find OUTPUT (results of your INPUT).

There are three places for INPUT:
The FILE MENU for creating or loading planets;
The EDIT WINDOW for making local changes to spots on the planet; and
The MODEL CONTROL PANELS for modifying the simulation and changing the planet globally.

The MODEL CONTROL PANELS are the only places in SimEarth that are INPUT only.

Everything else—all the maps and graphs, even the EDIT WINDOW—supplies OUTPUT.

TIME LIMIT

In SimEarth, as on the real Earth, the level of solar radiation is continually increasing. You only have 10 billion years before the planet gets so hot that all life on it will die.

Technically, the Sun cools off as it expands into a red giant. As it expands, it gets closer to the planet. From the planet's position, the solar radiation is increasing even though the Sun is cooling.

TIME SCALES

There are four Time Scales in SimEarth: Geologic, Evolution, Civilized, and Technology. Each Time Scale simulates different periods of a planet's development at different rates of speed.

You can begin a planet in any Time Scale, or start at the first (Geologic) and guide your planet through them all. A certain amount of development must occur before advancing to the next one.

BIOMES

Biomes are ecological systems of plants and animals, such as Forest, Desert and Jungle. Where a particular biome can survive depends on temperature, rainfall and altitude. For the most part, biomes are used in SimEarth to represent the plant life of a planet.

LIFE

Life-forms in SimEarth (SimEarthlings) range from single-celled microbes in the ocean to complex, intelligent animals. Any multicellular life-form in SimEarth can become intelligent.

Life will begin and evolve automatically in SimEarth. To a great extent, you can affect the evolutionary path that life follows on your planet.

There are 15 classes of life represented in SimEarth. Each class of life has 16 species. There are 240 possible forms of life, but not all of them will develop or survive on any given planet.

The symbols that represent life in the EDIT WINDOW stand for a large population of that life-form—not just one animal.

Each form of life has favorite biomes where it flourishes, and others where it cannot survive at all.

The level of development of life controls the advancement of Time Scales.

CIVILIZATION

Eventually, one type of SimEarthling will attain sentience. When this happens, civilization begins. With civilization comes many new issues and problems to deal with.

SimEarth simulates civilization with cities at seven levels of technology ranging from the Stone Age of the distant past to the Nanotech Age of the future.

ENERGY

There are two uses of energy in SimEarth: yours and the SimEarthlings.

You use energy each time you change the planet in the EDIT WINDOW or the MODEL CONTROL PANELS. Creating and nurturing your planet within your energy budget is one of the challenges of SimEarth.

Intelligent SimEarthlings produce and use energy. You can control their energy production and use, but it's theirs—you can't use their energy for planet manipulation.

HELP AND THE GLOSSARY

On-line help is available anywhere at any time in SimEarth. To access help, hold down the SHIFT KEY and click somewhere on the screen. A text window will appear with the information you need.

One special use of the HELP WINDOW is the GLOSSARY. There may be some words that you don't know in this program. If you choose GLOSSARY from the WINDOWS MENU, a glossary of the words and terms used in this program will appear in the HELP WINDOW.

ABOUT THIS TUTORIAL

This tutorial will be presented in three sections:

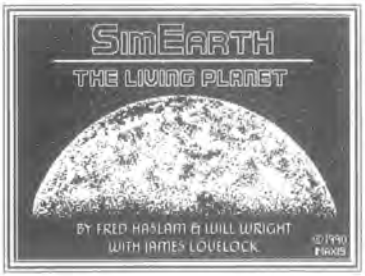
FIRST LOOK will introduce you to the various menus, windows, graphs, and control panels.

CREATING AND MODIFYING PLANETS will teach you how to create and save planets; change the landform of a planet; place and move biomes, life and cities on a planet; and trigger events such as volcanos and earthquakes.

MODIFYING THE SIMULATION shows how you can use the MODEL CONTROL PANELS to change global conditions on your planet.

FIRST LOOK

See the system card and addendum for your machine for installation and startup instructions, and fire it up.

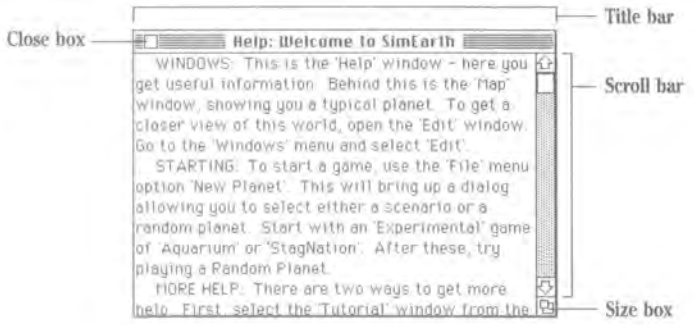


You will see a MENU BAR across the top of the screen, plus three separate windows: a TITLE SCREEN, a HELP WINDOW, and the MAP WINDOW.

The TITLE SCREEN introduces the program and gives credits. Click on it to make it go away.

The HELP WINDOW holds text that will help you use and understand SimEarth. You can request help on any icon, any button, any window, any function, any anything in SimEarth.

The first time you start the program, the HELP WINDOW will display text to help you get started.

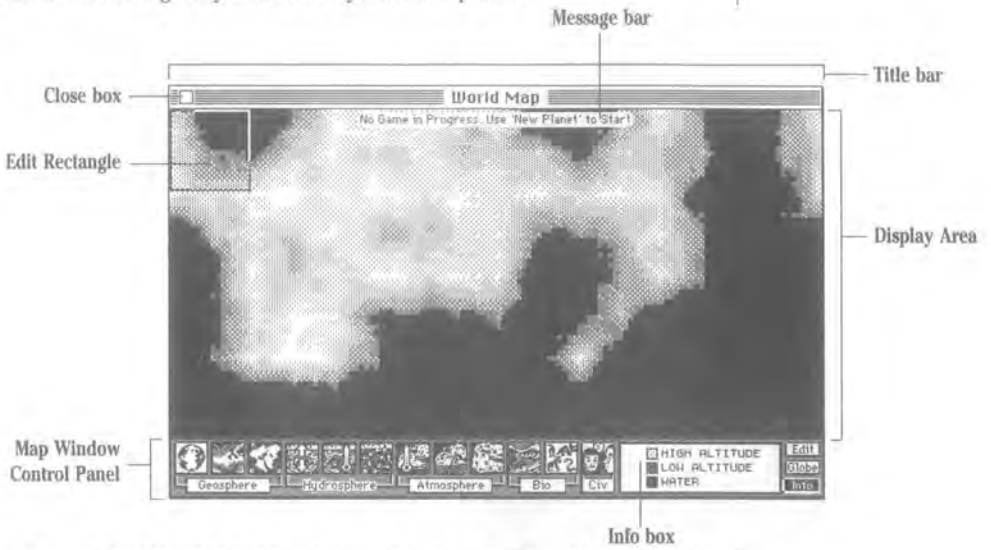

Close box
Help: Welcome to SimEarth
WINDOWS: This is the 'Help' window - here you get useful information. Behind this is the 'Map' window, showing you a typical planet. To get a closer view of this world, open the 'Edit' window. Go to the 'Windows' menu and select 'Edit'.
STARTING: To start a game, use the 'File' menu option 'New Planet'. This will bring up a dialog allowing you to select either a scenario or a random planet. Start with an 'Experimental' game of 'Aquarium' or 'StagNation'. After these, try playing a Random Planet.
MORE HELP: There are two ways to get more help. First, select the 'Tutorial' window from the
Title bar
Scroll bar
Size box

You can change the size of the HELP WINDOW by clicking and dragging the SIZE BOX. You can move it around the screen by clicking and dragging the TITLE BAR.

To scroll through all the text in a HELP WINDOW click on the up or down arrows in the SCROLL BAR on the right side of the window.

To make the HELP WINDOW go away, click in the CLOSE BOX.

The MAP WINDOW gives you a view of your entire planet.



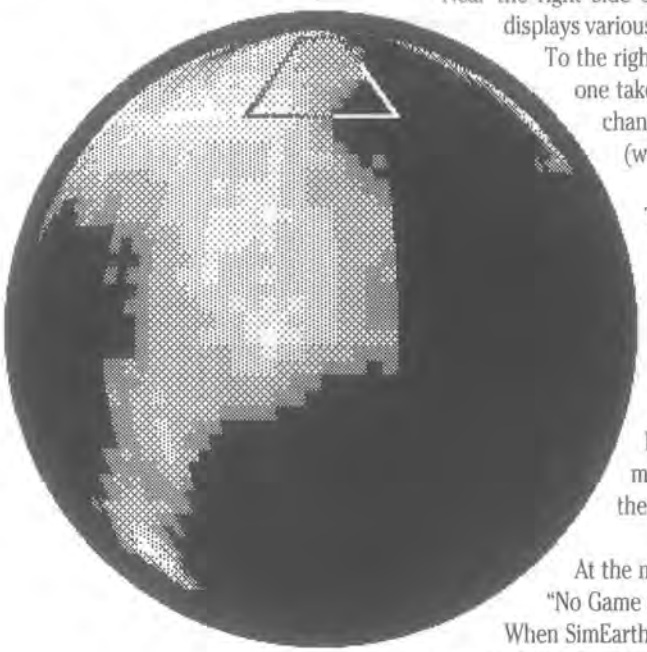
At the top of the MAP WINDOW is the TITLE BAR. It displays the name of the current map display. You can move the MAP WINDOW around the screen by clicking and dragging the TITLE BAR. At the left of the TITLE BAR is the CLOSE BOX. If you click in this box the MAP WINDOW will close. To bring it back, select MAP from the WINDOWS MENU.

All windows, graphs and control panels have TITLE BARS and CLOSE BOXES.

The MAP WINDOW also has a DISPLAY AREA and a CONTROL PANEL. The DISPLAY AREA shows the entire planet. A rectangle somewhere in this area shows the part of the planet that will be displayed in the EDIT WINDOW, your close-up view of the planet.

The CONTROL PANEL, at the bottom of the window, lets you select different views of the planet that give you information about the land, water, air, climate, life and civilization. The views are changed by clicking on the 12 icons. Go ahead and click on them. Many of them won't do much because there is no active planet. To get the original view back, click on the far left icon.

Clicking on the little buttons at the bottom that say GEOSPHERE, ATMOSPHERE, BIO, and CIV will bring up various MODEL CONTROL PANELS, and double-clicking on some of the icons will bring up graphs. Don't worry about this now. If an unexpected small window pops up, close it by clicking in its CLOSE BOX, or just click on any part of the MAP WINDOW to bring it to the front.



Near the right side of the CONTROL PANEL is the INFO BOX. It displays various graphs and legends for each of the map views. To the right of the INFO BOX are three buttons. The top one takes you to the EDIT WINDOW; the bottom one changes the INFO BOX between graphs and legends (when available).

The middle button, GLOBE, changes the flat map into a globe. All of the map views are available on both the flat map and the globe. Click on GLOBE again to return to the flat map.

At the top of the DISPLAY AREA is a MESSAGE BAR that will sometimes appear and display messages to you from the simulation and from the SimEarthlings that inhabit the planet.

At the moment, the MESSAGE BAR should say,
"No Game in Progress. Use 'New Planet' to Start."
When SimEarth first starts, there is no actual planet or game running. This gives you a chance to look around a little before things start to happen. When you are ready to start playing, you must choose NEW PLANET from the FILE MENU.

Before doing that, we'll take a quick look around.

Look at the MENUS along the top of the screen. If you are unfamiliar with drop-down menus, check with the SimEarth addendum for your machine. A complete description of every item on every menu is found in the Reference section of this manual.

Open the FILE MENU. It is for starting new planets, loading and saving old planets, printing, and quitting SimEarth.

Open the WINDOWS MENU. Use this menu to open the various SimEarth windows.

Open the MODELS MENU. This menu gives you access to the four MODEL CONTROL PANELS that you will use to modify the simulation.

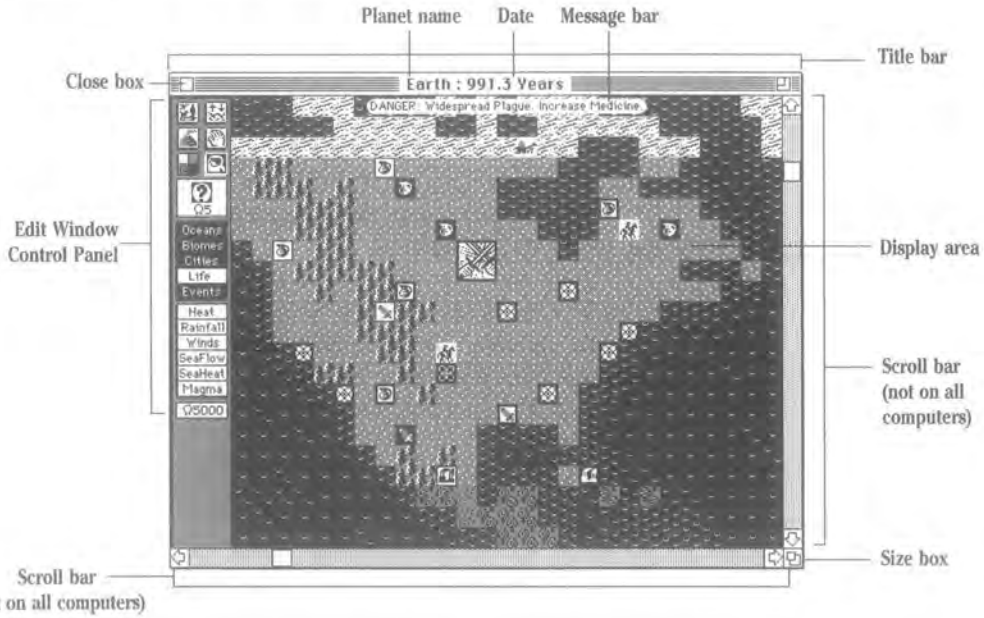
Open the GRAPHS MENU. This menu gives you access to the four graphs that give you information on air, life and technology on the planet.

Open the OPTIONS MENU. It lets you customize the program to your tastes.

Open the SPEED MENU. It lets you set the simulation speed of the game and choose the way the date is displayed.

Open the DATASOUND MENU. It lets you control some of the sound in SimEarth.

Along with the MAP WINDOW, the most important window you will be using is the EDIT WINDOW. To see it, choose EDIT from the WINDOWS MENU. For a complete description of everything in the EDIT WINDOW, see the Reference section of this manual. Here's a once-over.



The EDIT WINDOW is your close-up view of your planet. It is where you will make modifications to the planet itself and the life on it.

The EDIT WINDOW also has a TITLE BAR, CONTROL PANEL, and a DISPLAY AREA. You can use the TITLE BAR to close or move the window. The DISPLAY AREA shows the area of the planet that is in the rectangle in the MAP WINDOW.

Edit Window Control Panel

On the left side of the window is the EDIT WINDOW CONTROL PANEL. This is where you choose your tools to modify the planet, and choose the data you want to view in this window.

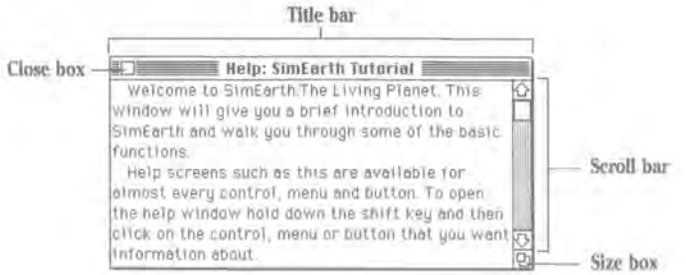
An easy way to find out what all the icons and buttons on the EDIT WINDOW CONTROL PANEL do is to use the HELP function. Hold down the SHIFT KEY and click on an icon or button. The HELP WINDOW will give you information on the spot where you clicked.

In the lower-right corner is the SIZE BOX. Click and drag this box to enlarge or shrink the size of the EDIT WINDOW.

The biggest part of this window is the DISPLAY AREA. This is the close-up "satellite's eye view" of your planet. At this point you will see only land and water in this area. The elevation of the land is shown in shades—the lighter the shade, the higher the elevation.

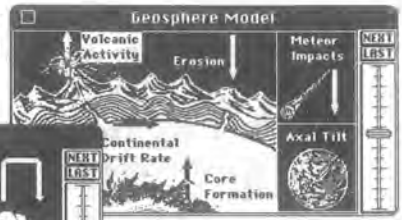
To see different parts of the planet you must scroll the planet's terrain under the window. Depending on your computer, you may or may not have SCROLL BARS at the right and bottom of the EDIT WINDOW. If you have SCROLL BARS, then use them (click on the arrows or the bar) to scroll the terrain. If you don't have SCROLL BARS, then simply move the mouse pointer to any edge or corner of the screen, and the display will scroll.

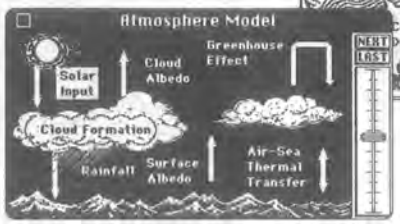
Go to the WINDOWS MENU and open the TUTORIAL WINDOW. This is a HELP WINDOW that introduces you to SimEarth and explains much of the program. The tutorial that you are reading now is much more complete. Use the on-line TUTORIAL WINDOW for a quick refresher course whenever you need it.


Title bar
Close box
Help: SimEarth Tutorial
Welcome to SimEarth:The Living Planet. This window will give you a brief introduction to SimEarth and walk you through some of the basic functions.
Help screens such as this are available for almost every control, menu and button. To open the help window hold down the shift key and then click on the control, menu or button that you want information about.
Scroll bar
Size box

There is also a HISTORY WINDOW that graphs 15 factors through the history of your planet, and a REPORT WINDOW, which gives you feedback on your planet's condition and your planet management skills. Since there is no active planet yet, these windows won't tell you much. We'll come back to them later.

Open the MODELS MENU and select GEOSPHERE. You will see the GEOSPHERE MODEL CONTROL PANEL. Go back to the menu and select ATMOSPHERE to see another CONTROL PANEL.





These CONTROL PANELS, four in all, let you modify the actual simulation. You can only display one MODEL CONTROL PANEL at a time. You can switch between them by clicking on the NEXT or LAST buttons in the upper-right corner of the panel.

Open the GRAPHS MENU and select one of the graphs. Only one graph can be viewed at a time. These graphs keep you informed on the status of the Atmosphere, Biomes, Life, and Technology on your planet.

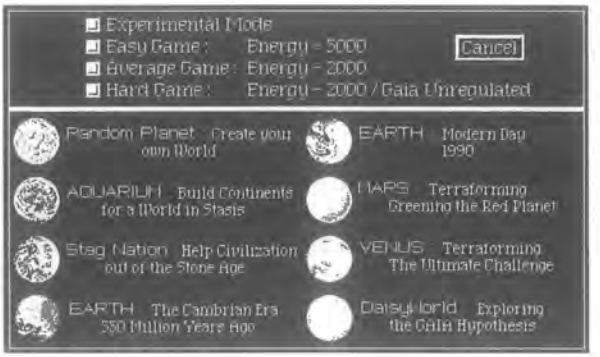
Let's build some planets.

CREATING AND MODIFYING PLANETS

CREATING A PLANET IN THE GEOLOGIC TIME SCALE

Select NEW PLANET from the FILE MENU.

You will see the NEW PLANET WINDOW.


Experimental Mode
Easy Game: Energy = 5000
Average Game: Energy = 2000
Hard Game: Energy = 2000 / Gaia Unregulated
Cancel
Random Planet: Create your own World
EARTH: Modern Day 1990
AQUARIUM: Build Continents for a World in Stasis
MARS: Terraforming Greening the Red Planet
Stag Nation: Help Civilization out of the Stone Age
VENUS: Terraforming The Ultimate Challenge
EARTH: The Cambrian Era 550 Million Years Ago
Daisyworld: Exploring the Gaia Hypothesis

At the top of this window, you select whether you want to play an easy, average, or hard game. You can also select experimental mode, which gives you an unlimited energy budget.

The bottom of the window gives you choices of planets. There are seven scenarios—pre-set planets—that you can load, or you can create a random planet.

Let's create a random planet in easy game mode. Click on EASY GAME in the top section of the window, and click on the planet that says RANDOM PLANET.

Now you will see a dialog box asking you to name your planet and select the Time Scale.

There are four Time Scales in SimEarth; each simulates different aspects of planetary development. There is a complete description of each Time Scale in the Reference section.

Click in the box next to GEOLOGIC (it may already be selected), then type in a name for your planet—try GEOWORLD—and click the BEGIN button.

A new planet is born. Select the EDIT option in the WINDOWS MENU and look at the EDIT WINDOW. In the TITLE BAR, along with the planet's name, is the date—the elapsed time since the planet was created. In the SPEED MENU you can change the format of the date between RELATIVE DATE (time elapsed since the beginning of the present Time Scale) and ABSOLUTE DATE (time elapsed since the creation of the planet). Since this planet is in the first Time Scale, the two are the same.

There will be no oceans for a while, and there is no atmosphere to burn up incoming meteors.

Sit back for a couple minutes and watch, switching between the EDIT and MAP WINDOWS. You will witness events: meteor strikes, volcanos, and earthquakes. Soon oceans will form and life will form in the oceans.

TOURING THE PLANET

Bring the EDIT WINDOW to the front, and make it as big as you can. Scroll around the planet and go sightseeing for a few minutes.

A lot is going on: time is passing very fast in this Time Scale. You can see the continents drifting. Single-celled life is spreading. Meteors hit the land and make craters that become lakes or hit the ocean and cause tidal waves.

EDIT WINDOW CONTROL PANEL

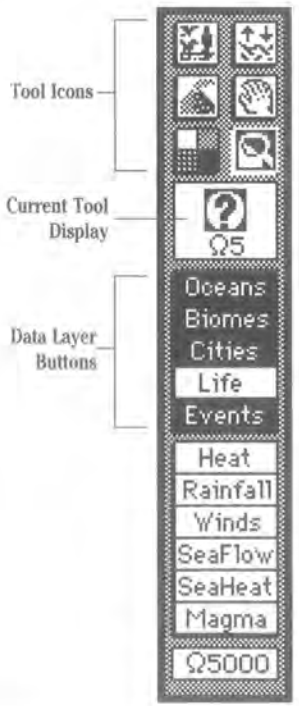
Bring the EDIT WINDOW to the front and look at the EDIT WINDOW CONTROL PANEL. At the top-left of the panel are six icons. Click on these icons to activate tools for changing the planet. Below that is the CURRENT TOOL DISPLAY. It shows which tool is being used and the cost in energy to use it.

Click on each icon. The three on the left have submenus. Click and hold to see them. Keep the mouse button down, and slide the pointer to an option on the submenu to select it.

To get an explanation of what an icon does, hold down the SHIFT KEY and click on the icon. The HELP WINDOW will explain what it does and how to use it.

Below the icons are the DATA LAYER BUTTONS—five buttons that let you decide what information about the planet will be displayed. You can have any, all, or none of these on at once.

You can also get HELP WINDOW messages about these buttons.



Click on these, and play with them. When you turn off the display of the oceans, you can see the elevation of the ocean floor. This doesn't make the ocean go away, it just makes it invisible. Depending on how fast you read, and how fast your computer is, you may or may not have life or biomes to turn on and off at this time.

Below the DATA LAYER BUTTONS are the CLIMATE OVERLAY BUTTONS—six buttons that let you turn on and off display of climactic information. Only one of these can be on at a time.

You can also get HELP WINDOW messages about these buttons.

Go ahead and play with these for a while.

At the bottom of the EDIT WINDOW CONTROL PANEL is the AVAILABLE ENERGY DISPLAY. In SimEarth, the price you pay to manipulate the planet is in energy. This little box tells you how much you have left. As time passes, your energy supply will slowly build back up, but it will never exceed 5000 in an easy game, or 2000 in an average or hard game. In experimental mode, you have unlimited energy.

USING THE SET ALTITUDE TOOL

This tool has two modes: RAISE and LOWER. Click once on the SET ALTITUDE icon. The icon will be highlighted. In the CURRENT TOOL DISPLAY, you will see the SET ALTITUDE icon, but with only an up arrow along with the cost to use it: 50 Ω (energy units).

Only the up arrow is shown to indicate that this tool is in RAISE mode.

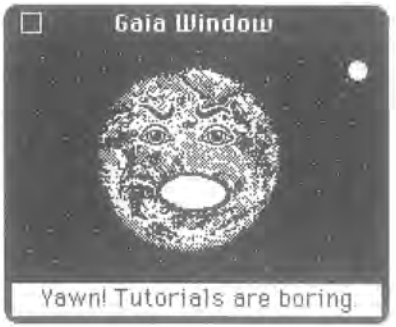
Scroll the EDIT WINDOW to a place on the planet that is mostly water (make sure the display of oceans is on). Point to the water and click and hold for a few seconds. You've just built an island. If you watch for a while, you'll notice that the island moves and changes. That is because time is moving so fast in this Time Scale that you can see the continents moving (continental drift).

Now click on the SET ALTITUDE icon again. The icon in the CURRENT TOOL DISPLAY shows only a down arrow to indicate that the tool is in LOWER mode. The price to lower altitude is also 50 energy units.

Scroll over to a landmass, click and hold for a few seconds. You've just dug a lake.

THE GAIA WINDOW

Select GAIA from the WINDOWS MENU. A small window appears with a representation of Gaia—the planetary organism. This face will give you constant feedback on the "mood of the planet."



Gaia's mood is based on how well life on the planet is doing. The moods range from bliss to horror. Everything that happens and everything you do affects the planet's mood.

You may want to keep this window showing in a corner of the screen to give you constant feedback on your planetary management.

Gaia will sleep until life forms, then it will wake up. Its eyes will follow the pointer around the screen. Please don't poke it in the eye.

TRIGGERING EVENTS

Now for some real fun—triggering events. Make sure the EVENTS DATA LAYER BUTTON in the EDIT WINDOW CONTROL PANEL is on.

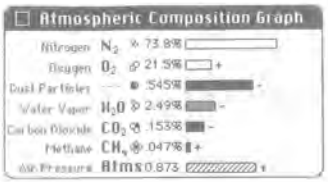
Events are more than just disasters or occurrences: they are tools. They can be helpful in shaping the land and changing the composition of the atmosphere. They can also cause mass extinctions.

Remember, in SimEarth, everything is interrelated. To see how each event can be used for good or bad, and its side effects that affect the planet, see the "Events" chapter of the Reference section and use the HELP function (hold the SHIFT KEY and click on the TRIGGER EVENTS icon).

METEORS

Click and hold on the TRIGGER EVENT icon. You will see the submenu of events. Slide the pointer until METEOR is highlighted, then release the mouse button.

Scroll the EDIT WINDOW so water is showing. Click a few times on the ocean. Meteors will crash into the water, creating tidal waves. When meteors hit the water, they add a lot of moisture to the air, which will increase rainfall and contribute to the greenhouse effect. To check this, select AIR SAMPLE from the GRAPHS MENU, which will open the ATMOSPHERIC COMPOSITION GRAPH. Look at the percentage of Water Vapor. Go back to the EDIT WINDOW and drop a few more meteors in the ocean. Check the Water Vapor percentage again.



Crash a few meteors into land. You will get huge craters. If they are deep enough, they will become lakes. Crashing meteors into land spews dust into the atmosphere. Too much dust in the air blocks sunlight, which will kill plants (biomes), which will kill animals. Check the dust levels in the ATMOSPHERIC COMPOSITION GRAPH before and after triggering meteors.

VOLCANOS

Click and hold on the TRIGGER EVENT icon again, and select VOLCANO from the submenu.

Trigger a volcano somewhere in the ocean—instant island. Volcanos in the water cause tidal waves, which can kill land life near the coasts. Volcanos also add dust and carbon dioxide to the atmosphere.

EARTHQUAKES

Now activate EARTHQUAKE on the TRIGGER EVENTS submenu. It has a sub-submenu for choosing the direction of the earthquake's energy. Earthquakes in SimEarth let you change the direction of the magma flow under the surface of the earth, which affects continental drift. In other words, earthquakes let you move continents. To easily see the results of earthquakes, turn on the MAGMA CLIMATE LAYER BUTTON.

You can use earthquakes to build mountain ranges. Center the EDIT WINDOW over a landmass, preferably an area at a low altitude (you can use the SET ALTITUDE tool to lower it). Near the top of the window, set off a few earthquakes that expend their energy to the south. Near the bottom of the window, set off a few earthquakes that expend their energy to the north. This has the effect of squeezing the land from both sides, and a mountain range will be pushed up where the energy from the southbound and northbound quakes meet.

OTHER EVENTS

The other events work the same way—they are useful tools with both good and bad side effects. Take some time and play with them.

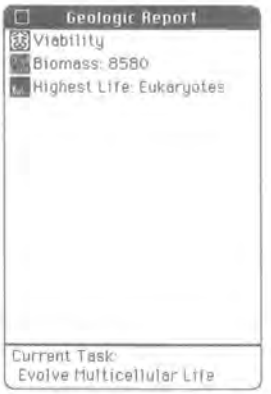
REPORT WINDOW

Open the WINDOWS MENU and select REPORT. The REPORT WINDOW tells you how you, your planet, and your planet's life are doing.

The information displayed in the REPORT WINDOW varies for each Time Scale. There is also a special REPORT WINDOW for the Daisyworld scenario and for the two terraforming scenarios (Mars and Venus).

At the bottom of the window is your CURRENT TASK. This is what must be accomplished before advancing to the next Time Scale, or successfully completing a scenario.

Let's start a new planet in the Civilization Time Scale and look at the rest of our tools.



CREATING A PLANET IN THE CIVILIZATION TIME SCALE

First, save the old planet to disk. Select SAVE AS... from the FILE MENU. Choose the disk or directory you want to save to, and change the name of the planet if you wish. Click the SAVE button. Refer to the SimEarth addendum for details.

Select NEW PLANET from the FILE MENU. This time, choose experimental mode, then click on the random planet.

When the Name and Time Scale dialog box appears, click in the box to the left of "Civilized," type in the name CIVWORLD, and click the BEGIN button.

Experimental Mode
Easy Game : Energy = 5000
Average Game : Energy = 2000
Hard Game : Energy = 2000 / Gaia Unregulated
Cancel
Random Planet : Create your own World
EARTH : Modern Day 1990
AQUARIUM : Build Continents for a World in Stasis
MARS : Terraforming Greening the Red Planet
Stag Nation : Help Civilization out of the Stone Age
VENUS : Terraforming The Ultimate Challenge
EARTH : The Cambrian Era 550 Million Years Ago
Daisyworld : Exploring the GAIA Hypothesis

INVESTIGATING THE NEW WORLD

MAP WINDOW

Lets take a look around the new planet. Open the MAP WINDOW, if it isn't already open, and have it display the world in the flat projection (not the globe). At the bottom of the window is the MAP WINDOW CONTROL PANEL.

In this control panel are 12 icons that change the map display. They are arranged in five groups: Geosphere, Hydrosphere, Atmosphere, Bio(sphere), and Civ(ilization).

The map now displayed is the Terrain Map, which corresponds with the Terrain Map icon. Here you can see the continents and the oceans, and the terrain level of the land. Click on the INFO BUTTON in the lower-right corner of the window. The INFO BOX now displays a legend to the map's altitude.

Click on the Event Map icon. Now the map shows the land and water (no altitude), plus tiny symbols that appear where events are occurring (if they are occurring). The INFO BOX shows a legend to the event symbols.

Click on the Drift Map icon. Now you see the direction of the magma currents, which controls continental drift on your planet.

Click on the Terrain Map icon. The drift is gone, and the altitude display is back.

The first icon in the Hydrosphere group is the Hide/Show Oceans icon. This toggles on and off the view of the oceans. It can be used along with any of the other icons. Click on it a couple times, but when you are done, leave the display of oceans on.

Click on the Ocean Temperature icon. You are shown the temperature of the ocean in shades or colors. The INFO BOX displays a legend of the temperatures.

Click on the next icon to see a display of ocean currents.

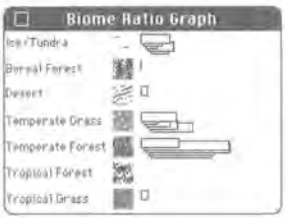
Now for the Atmosphere group. The three icons in this group display Air Temperature, Rainfall, and Air Currents, respectively. Click on each of them. The INFO BOX will display a legend for each display.

The Biosphere group only has two icons: Biomes shows the biome distribution on the planet, and Life shows the diversity of life on the planet. Once again, the INFO BOX displays a legend to help you interpret the map.

There is only one icon in the Civilization group. It displays the distribution of the seven levels of Technology on the planet.

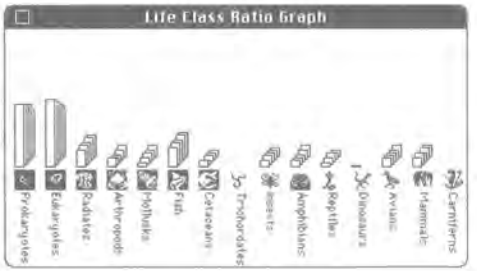
GRAPHS

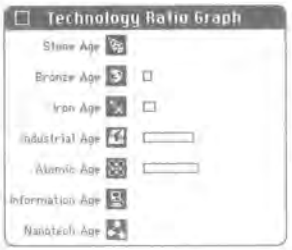
The graphs will also give you information about this planet. Select BIOMES from the GRAPHS MENU to see the BIOME RATIO GRAPH.



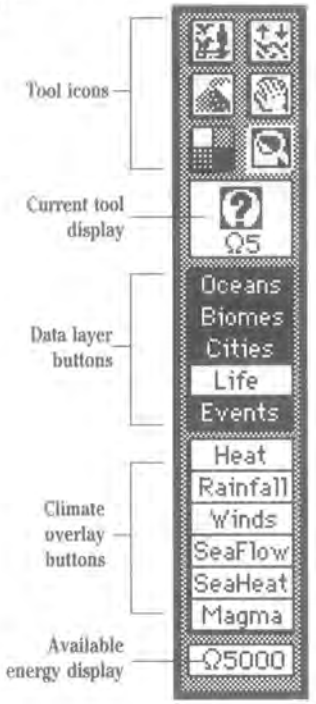
This graph shows the relative amounts of each biome on the planet. Since it shows changes over time, you can see the rise and fall of biomes through time.

Select LIFE-FORMS from the GRAPHS MENU to see the LIFE CLASS RATIO GRAPH. This shows the relative amounts of each class of life on the planet.





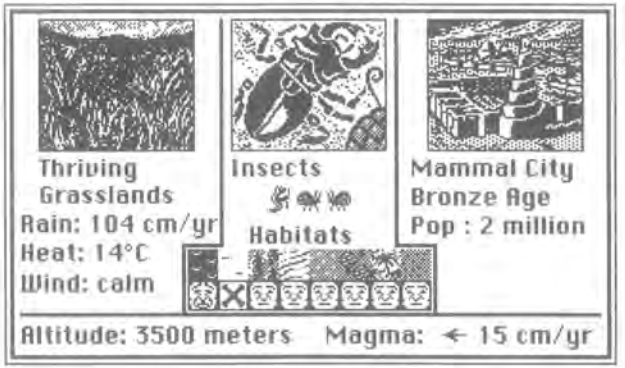
Select TECHNOLOGY from the GRAPHS MENU to see the TECHNOLOGY RATIO GRAPH. This shows the relative amount of each level of technology on the planet.



EDIT WINDOW

Go back to the EDIT WINDOW, and look at the EDIT WINDOW CONTROL PANEL. Turn on all the DATA LAYER BUTTONS.

Click on the EXAMINE icon. Now click and hold on any spot in the EDIT WINDOW DISPLAY AREA. A small window will pop up on the screen that gives you data on the biomes, life, and civilization in that spot.



While still holding down the mouse button, move the pointer around the EDIT WINDOW. The data window will update to describe the spot under the pointer. Take some time and use the EXAMINE tool to explore your world.

If you ask for HELP (hold down the SHIFT KEY and click) in the EDIT WINDOW DISPLAY AREA it will bring up the same data window as the EXAMINE tool.

Now that we know something about the planet, let's shake things up a little.

THE PLACE LIFE TOOL

Make sure the EDIT WINDOW is displayed, and the LIFE and CITIES DATA LAYER BUTTONS are on. Click and hold on the PLACE LIFE icon.

You will see a submenu. This is where you choose life, civilizations (cities), and terraformers to place on your planet.

The left side of the submenu is for selecting life. The top seven are sea life, the bottom seven are land life.

On the right side, the top seven items are cities for your intelligent SimEarthlings. The seven cities represent seven levels of technology. Below the cities are seven terraformers. These are tools that you will need to terraform Mars and Venus.

Select one of the life-forms on the left side of the submenu. Move the pointer to the EDIT WINDOW DISPLAY AREA and click. The life-form will be placed where you click.

Depending on the Time Scale and level of development on the planet, some of the options on the Place Life submenu will not be available. These include both life-forms and cities.

Just because you place life on the planet doesn't mean it will stay there. If you place ocean life on the land or land life in the water, it won't last long. Also, life-forms can only survive well in certain biomes.

A complete chart of what life can live in which biome is in the "Life" chapter in the Reference section of this manual.

Notice that placing different life-forms and cities costs different amounts of energy, depending on the level of advancement of the item you are placing.

THE PLANT BIOME TOOL

Just as you can place animal life on the planet, you can plant biomes. Click and hold on the PLANT BIOME icon. You will see a submenu that will allow you to choose a biome to plant.

The various biomes can only survive in certain climates—if you plant a swamp in a polar icecap, it won't last long. A complete chart of what biomes can survive in which climates is in the "Life" chapter in the Reference section.

When planting biomes, you can click and hold the mouse button, and slowly drag the mouse across the planet. The biomes will be continuously "painted" onto the terrain.

THE MOVE TOOL

The last tool in the EDIT WINDOW is for moving biomes, life, and cities. Click on the MOVE icon.

Move the pointer to the EDIT WINDOW DISPLAY AREA and click and hold on a spot with life, a city, or a biome. Move the pointer to a different spot, and release the mouse button.

Besides moving things, the MOVE tool is helpful for investigation. When you have multiple data layers on, LIFE symbols will cover BIOME symbols, and CITY symbols will cover both LIFE and BIOMES. To see what life or biome is under a city, use the MOVE tool to lift it, then put it back in the same place.

We've covered exploration and modification of the planet; now we'll learn how to modify the simulation.

MODIFYING THE SIMULATION

INTRODUCTION

In the EDIT WINDOW you change the planet. In fact, you only change part of the planet. With the MODEL CONTROL PANELS, you make changes to the actual model that controls the fate of the entire planet.

There are four MODEL CONTROL PANELS. One each to modify the simulation in the following areas:

GEOSPHERE—the planet itself;
ATMOSPHERE—the planet's air and climate;
BIOSPHERE—life on the planet; and
CIVILIZATION—the behavior of the planet's sentient species.

This tutorial won't explain each and every control on each CONTROL PANEL. It will explain what each CONTROL PANEL does, and how to use it. For a complete description of the control panels, see the "Model Control Panels" chapter in the Reference section.

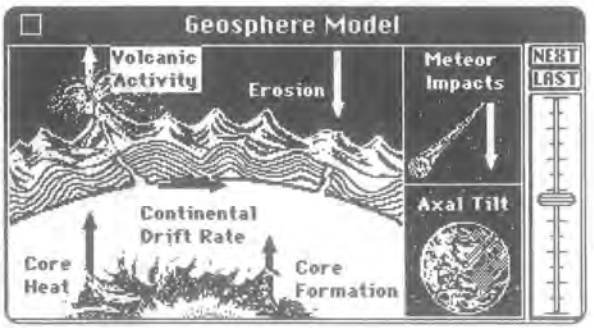
You can also find out what each control does by using the HELP function: hold down the SHIFT KEY and click on one of the controls. A HELP WINDOW will appear with a description of what each individual control does.

GEOSPHERE MODEL CONTROL PANEL

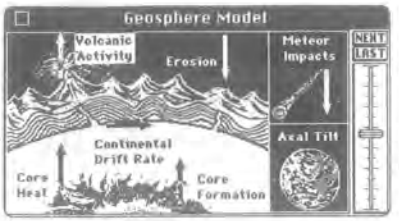
The GEOSPHERE MODEL CONTROL PANEL controls the geologic aspects of a planet. These aspects, such as continental drift and core formation, change very slowly over millions of years. Since they change so slowly, the only way to see them clearly is in the Geologic Time Scale.

Create a new, random planet in the Geologic Time Scale.

Close all the windows, except the MAP WINDOW. Open the GEOSPHERE MODEL CONTROL PANEL. You can either do this by selecting GEOSPHERE from the MODELS MENU, or by clicking on the GEOSPHERE button in the MAP WINDOW CONTROL PANEL.



Open the OPTIONS MENU and make sure UPDATE BACKGROUND is on. (It will have a checkmark on the left if it is on.) This will allow you to keep the MODEL CONTROL PANEL in front, and still see the changes in the MAP WINDOW.



There are seven controls on this panel. Each control has a name and an indicator. The indicator is usually an arrow. For this tutorial, we'll concentrate on the CONTINENTAL DRIFT control because the results of changing it are easy to see.

Click on the words CONTINENTAL DRIFT in the GEOSPHERE MODEL CONTROL PANEL. The words and the arrow above those words will be highlighted to show that this control is ready for your changes.

To change the settings, you will use the slider control on the right side of the control panel. Click above or below the slider to move it up or down one notch. You can also click and drag the slider.

If the oceans haven't formed yet on your newest planet, wait a minute until they do, then continue.

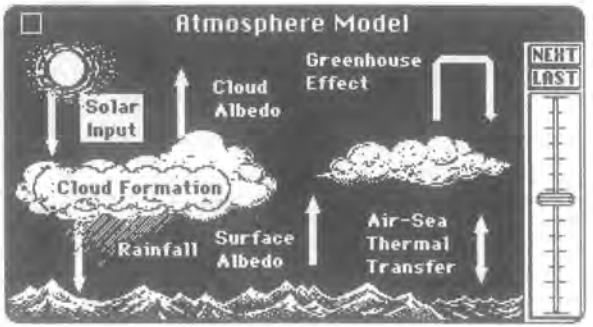
Click and drag the slider all the way to the top, turning continental drift to its maximum setting. Go to the SPEED MENU and set the simulator to FAST. Watch the MAP WINDOW for a while: you will actually see the continents moving.

Now turn the continental drift all the way down. The continents will slow their movement to nearly nothing.

The other controls are operated the same way, and though the results of changing them isn't as obvious as with continental drift, they all have a powerful impact on the planet.

ATMOSPHERE MODEL CONTROL PANEL

Now open the ATMOSPHERE MODEL CONTROL PANEL. You can open it three ways: select ATMOSPHERE from the MODELS MENU, click on the ATMOSPHERE button on the MAP WINDOW CONTROL PANEL, or click the NEXT button in the upper-right corner of the GEOSPHERE MODEL CONTROL PANEL.



The ATMOSPHERE MODEL CONTROL PANEL is effective in all four Time Scales.

Bring the MAP WINDOW to the front, and click on the AIR TEMPERATURE icon. Click on the INFO BUTTON to display a color/shade legend of the temperatures.

Bring the ATMOSPHERE MODEL CONTROL PANEL to the front. Click on SOLAR INPUT, then drag the slider all the way to the top. You just turned the heat from the Sun to maximum. Your planet will soon start warming up.

To add insult to injury, turn GREENHOUSE EFFECT all the way up, and turn CLOUD ALBEDO, SURFACE ALBEDO, and AIR-SEA THERMAL TRANSFER all the way down. Each of these actions will contribute to global warming.

Click on the INFO BUTTON. It will now display a graph of the changes in air temperature. Watch for a while. Soon the map and graph will show a rise in temperature. If you leave it rising long enough, your oceans will boil off and all life on the planet will die.

After a few minutes, set all the settings back to midway, and watch the map and graph as everything begins to cool down.

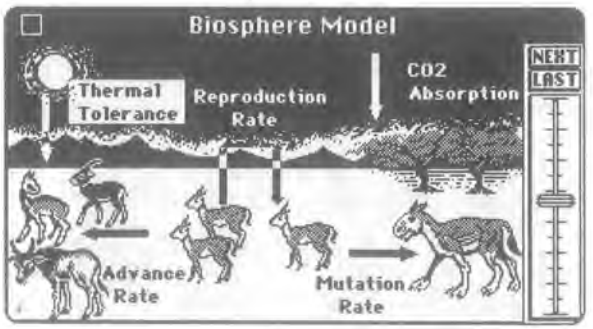
BIOSPHERE MODEL CONTROL PANEL

The BIOSPHERE MODEL CONTROL PANEL is most effective in Evolution Time Scale, but has some effect in the other Time Scales. It controls how the simulation models life on the planet.

Create a new planet in the Evolution Time Scale, set the simulation speed to FAST in the SPEED MENU, and open the BIOSPHERE MODEL CONTROL PANEL. It can be opened from the menu, the MAP WINDOW CONTROL PANEL, or the NEXT button on the ATMOSPHERE MODEL CONTROL PANEL.

Turn ADVANCE RATE, MUTATION RATE, and REPRODUCTION RATE on the BIOSPHERE MODEL CONTROL PANEL all the way up.

The changes from this control panel are much less obvious than the others. You can best see them in the HISTORY WINDOW.



HISTORY WINDOW

Open the HISTORY WINDOW by selecting HISTORY in the WINDOWS MENU.

The HISTORY WINDOW displays the changes in 15 factors over time. Click on the DIVERSITY button to display the changing number of species on the planet.

Watch for a few minutes, and the changes you made in the BIOSPHERE MODEL CONTROL PANEL will cause a rise in the diversity.

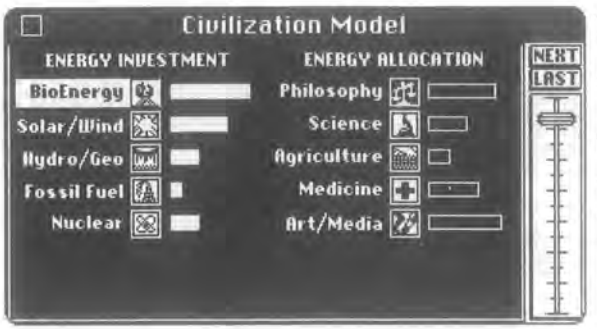
CIVILIZATION MODEL CONTROL PANEL

The CIVILIZATION MODEL CONTROL PANEL controls how the model deals with your intelligent species. It is only useful in the Civilization and Technology Time Scales.

Open the CIVILIZATION MODEL CONTROL PANEL. This control panel is one of the main challenges of SimEarth. You decide what energy sources the intelligent inhabitants of your planet will invest their time in, and what they will do with the energy.

This is a very complex control panel. For a complete explanation, see the "MODEL CONTROL PANEL" chapter in the Reference section of this manual.

The left side of the CIVILIZATION MODEL CONTROL PANEL is for choosing the energy sources to develop. These are set the same as settings on the other control panels. Different energy sources are appropriate for different levels of technology: you can make a Stone Age level civilization spend a lot of time trying to develop nuclear energy, but they don't have the knowledge or tools to succeed, and won't get any return from it.



The more you invest in energy forms that are appropriate for the technology level, the more energy the civilizations will have to use for advancement to the next technology level.

The right side of the control panel is where you allocate energy. You decide to what use the civilizations will put the energy they produce.

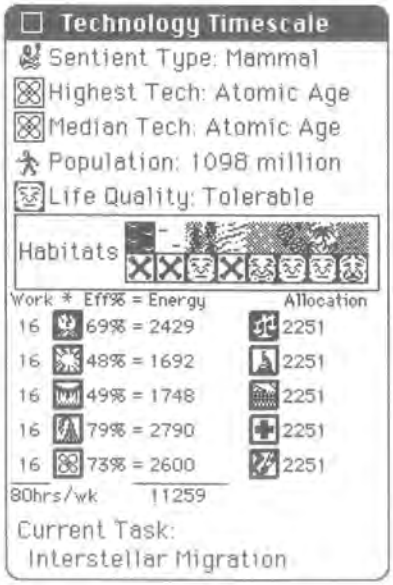
This side of the control panel works a little differently from the left side. It is a ratio. All energy that is produced is used. The higher the setting for each energy use, the higher the percentage of the produced energy will be allocated to that use. If the settings are all in the middle, or all the way up, the model interprets it the same. The important thing here is the relative settings of each energy use. Set your priorities and allocate to those uses you find most important.

The CIVILIZATION MODEL CONTROL PANEL is closely related to the REPORT WINDOW.

REPORT WINDOW

Create a new planet in the Technology Time Scale. Make sure the UPDATE BACKGROUND option is on.

Open the REPORT WINDOW, and arrange the screen so it and the CIVILIZATION MODEL CONTROL PANEL are both visible.



Take a look at the REPORT WINDOW. There is detailed information on the planet's civilized life. It tells you the class of your sentient species, the highest and average (median) technology level, the population, and quality of life. It also shows a chart of what biomes your sentient species prefers to live in.

Below that is a section on energy that relates to the CIVILIZATION MODEL CONTROL PANEL. It lists the energy sources, and their efficiency. The efficiency depends on the average level of technology on your planet.

To the left of each energy source are the hours per week your global citizen works on this energy source. Below these hours are the total hours per week intelligent SimEarthlings must work to survive.

As you turn the energy investments on the CIVILIZATION MODEL CONTROL PANEL up and down, the hours worked will rise and fall. Try it.

Keep this in mind when you set your energy investment—the work hours per week affect the SimEarthling's quality of life.

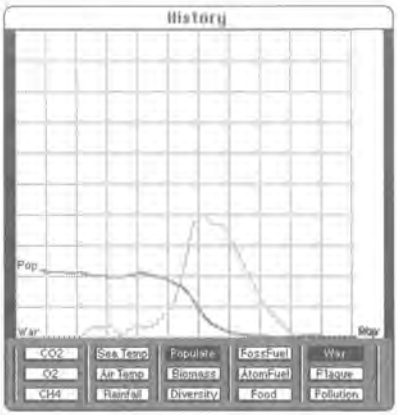
ALLOCATING ENERGY

Energy allocation in the CIVILIZATION MODEL CONTROL PANEL affects every aspect of the sentient SimEarthling's lives.

The results of your allocation are easy to see. Make sure the UPDATE BACKGROUND option is on.

For an easy-to-see example, we'll look at PHILOSOPHY.

Allocating to PHILOSOPHY lessens the frequency and severity of war. If you take all allocation away from PHILOSOPHY, wars will break out all over the planet. These wars can be viewed in the EDIT WINDOW and the HISTORY WINDOW.



Open the HISTORY WINDOW and arrange the screen so you can see it along with the CIVILIZATION MODEL CONTROL PANEL. In the HISTORY WINDOW, turn the POPULATE and WAR graphs on. Turn PHILOSOPHY all the way down in the CIVILIZATION MODEL CONTROL PANEL.

The occurrence of war will quickly rise. Eventually it will fall, because so many of the sentient SimEarthlings have been killed that there's no one left to fight.

Allocating or not allocating to the other energy uses can have results as drastic as PHILOSOPHY. These results can be seen in the EDIT, REPORT and MAP WINDOWS. Try turning each one all the way up, then all the way down and see what happens.

Allocating to SCIENCE will help your intelligent SimEarthlings advance to higher levels of technology. No allocation to SCIENCE will cause advancement to stop. Allocate too much and they will advance too fast, and kill themselves.

Allocating to AGRICULTURE affects the food supply.

Allocating to MEDICINE affects the frequency and severity of plagues.

Allocating to ART/MEDIA affects the quality of life on your planet.

Your task here is making difficult choices and setting priorities.

CONCLUSION

Now you know the basics of SimEarth:

Using menus;
Opening and closing windows;
Creating and saving planets;
Getting information from maps and graphs;
Changing the planet in the EDIT WINDOW; and
Changing the simulation in the MODEL CONTROL PANELS.

Mastery of planet management takes a lot of time and experimentation. You may even (heaven forbid) have to read the rest of this manual.

Happy simulating.

UNBLANK PAGE

To keep this manual consistent by always having a chapter title page on the right side, we either had to leave this page blank, say something dumb like "This page intentionally left blank," or fill it up with something.

Here are some profound thoughts and revelations that occurred to us while playing SimEarth.

EVOLUTIONARY THOUGHT

In general, SimEarthlings are as lazy as Earthlings. They never want to work, and especially hate physical labor. Whenever there are heavy objects to move, they argue over who has to do it.

"I don't want to carry it—you carry it!"
"Not me—you carry it."

And that's how *Eu*karyotes evolved.

Of course, the usual solution is to hire a professional to do the work. That's what *Pro*karyotes do for a living.

REVELATION #1

When you're sitting on top of the world, be careful not to break the monitor.

SIMEARTHLING EXTINCT BLUES

My life-form's gone, but I don't worry,

'Cause I'm simulating on top of the world.

NOBODY READS GAME MANUALS

Hi Mom. I know nobody reads game manuals, but I knew *you* would. I worked real hard on this manual, and...Mom...wake up Mom.

QUESTION

Where in the world *is* Carmen SimDiego?

REFERENCE

"Love makes the world go 'round but a single click in the edit rectangle makes it stop."

M. Bremer

CONTROLLING THE SIMULATION

OF MICE AND KEYBOARDS

Depending on your computer, you may or may not have a mouse. If you do have one, then you will want to use it—SimEarth is much easier to control with a mouse than with a keyboard.

See the addendum for your computer for more information on using mice and keyboards in SimEarth.

In general, you will use the mouse to select items from menus, and to activate tools by clicking on icons. Once tools are activated, SimEarth functions much like a paint program that "paints life on a planet."

INPUT AND OUTPUT

SimEarth has a lot of windows, graphs, and control panels, and can get confusing. The easiest way to understand the program is to know where you can INPUT information—add or change the planet or model to suit yourself—and where to see OUTPUT, the information about the planet and results of your INPUT.

INPUT

There are three places to INPUT information: the FILE MENU, the EDIT WINDOW, and the MODEL CONTROL PANELS.

FILE MENU

By selecting NEW PLANET or LOAD PLANET from the FILE MENU, you remove the existing planet or scenario from memory and load another planet or scenario into the simulation.

EDIT WINDOW

The EDIT WINDOW is where you place life, change altitudes and trigger events. When you do these things, you are INPUTTING DATA—changes to the planet. Since this only affects the planet in the locale of your input, we call this LOCAL INPUT.

The EDIT WINDOW is also a source of OUTPUT.

MODEL CONTROL PANELS

The four MODEL CONTROL PANELS are where you change the actual model. These changes affect the entire planet, and change the simulation itself. Since everything—the whole world—is affected, we call this GLOBAL INPUT.

The MODEL CONTROL PANELS are the only places in SimEarth that are INPUT ONLY.

OUTPUT

Other than the MODEL CONTROL PANELS, every window in SimEarth gives OUTPUT—information for you about the planet, the simulation, and the results of your input.

MENUS

FILE MENU

The FILE MENU is for performing file and disk-related functions.

NEW PLANET brings up the NEW PLANET WINDOW, which allows you to pick any of the seven included Scenarios, or a new, randomly generated planet/game in any of three difficulty levels or experimental mode.

First, choose the difficulty level. There are three levels of difficulty for games: easy, medium, and hard. There is also an experimental mode that gives you an unlimited energy budget for planet manipulation.

Next, pick a scenario or a random planet. If you choose random planet, you will be shown a dialog box allowing you to name your new world, choose the Time Scale, and either begin the new planet or cancel. If you have a planet in progress that has not been saved, you will be given the opportunity to save it before the new planet is generated.

LOAD PLANET brings up a dialog box to allow you to load in a pre-existing planet. If you have a planet in progress that has not been saved, you will be given the opportunity to save it before loading a new one. See the SimEarth addendum for your computer for details on loading planets.

SAVE PLANET saves your current planet to disk. If it has not been saved before, it will bring up a dialog box window to allow you to name your planet before saving it. See the SimEarth addendum for your computer for details on saving planets.

SAVE AS brings up a dialog box, allowing you to change the name and/or location of a previously saved planet.

PRINT or **SNAPSHOT** may or may not be present in your version of SimEarth. See the SimEarth addendum for your machine for details.

QUIT ends your SimEarth session, with a final chance to save your planet-in-progress.

WINDOWS MENU

The WINDOWS MENU allows access to the various windows in SimEarth.

EDIT opens and/or brings the EDIT WINDOW to the front.

MAP opens and/or brings the MAP WINDOW to the front.

GAIA opens the GAIA WINDOW, which displays the face of the planet and gives constant feedback on your actions and the state of life in the world.

HISTORY opens and/or brings the HISTORY WINDOW to the front.

REPORT opens and/or brings the REPORT WINDOW to the front.

TUTORIAL opens and/or brings the TUTORIAL WINDOW to the front.

GLOSSARY opens a HELP WINDOW that displays a glossary of many earth science terms used in SimEarth.

MODELS MENU

The MODELS MENU allows access to the various MODEL CONTROL PANELS that let you adjust the inner workings of the simulation.

GEOSPHERE opens the Geosphere Model Control Panel.

ATMOSPHERE opens the Atmosphere Model Control Panel.

BIOSPHERE opens the Biosphere Model Control Panel.

CIVILIZATION opens the Civilization Model Control Panel.

GRAPHS MENU

The GRAPHS MENU allows access to the various graphs used in SimEarth.

AIR SAMPLE brings up the Atmospheric Composition graph.

BIOMES brings up the Biome Ratio graph.

LIFE-FORMS brings up the Life Class Ratio graph.

TECHNOLOGY brings up the Technology Ratio graph.

OPTIONS MENU

The OPTIONS MENU lets you adjust many features of SimEarth to suit your personal preferences. When the options are active, a checkmark will appear to the left of the option.

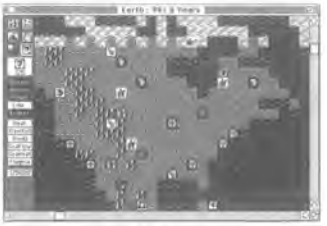
GOTO EVENTS automatically transports you to the location of any event that occurs. When this option is active, and when the EDIT WINDOW is in the front,

the area viewed in the EDIT WINDOW will jump to center on any events that occur. The default setting is off.

UPDATE BACKGROUND lets you choose whether or not all windows on the screen will be animated and constantly updated. When this option is inactive, only the front window will be animated and updated. Having this option on greatly decreases the speed of the simulation. The default setting depends on your machine's speed of operation.

This is especially useful for high-speed machines with large monitors. If SimEarth runs too slowly, or you rarely display more than one or two windows at a time, you may wish to turn this off.

COMPRESS EDIT SCREEN is an option that can be very useful on computers with small screens. When active, it changes the EDIT WINDOW so it only displays every other tile, allowing you to see four times as much area. The default setting is off.



Normal view

Compressed view

MUSIC enables and disables music during the game. The default setting is on.

SOUND EFFECTS enables and disables sound during the game. The default setting is on.

MESSAGES enables and disables the display of messages to you from the simulator and the SimEarthlings that will appear throughout the game. The default setting is on.

AUTOSCROLL allows automatic scrolling of the terrain in the EDIT WINDOW when using any of the EDIT WINDOW icons near or at the edge of the window. The default setting is on.

SAVE OPTIONS + WINDOWS saves your present configuration of options, open windows, window sizes and window locations to disk as the default configuration. You can use this option again at any time to change the default settings.

SPEED MENU

The SPEED MENU allows you to set the simulation speed and date options.

FAST sets the simulation speed to the maximum available for your machine.

MODERATE sets the simulation speed to approximately 75% of the fast setting. This is the default speed setting.

SLOW sets the simulation speed to approximately 25% of the fast setting.

PAUSE pauses the simulation. All the planet manipulation tools will be available and active, but time will be stopped.

RELATIVE DATE displays the date as the number of years since the beginning of the present Time Scale. This is the default date setting.

ABSOLUTE DATE displays the date as the number of years since the original cooling of the planet. If you began your planet in a later Time Scale, Absolute Date will estimate and add the time from earlier Time Scales.

DATASOUND MENU

The DATASOUND MENU controls the sound functions in SimEarth. The first two items are ways of using the sound, and the last seven items let you choose the data from which the sound will be generated.

TONE MONITOR plays an intermittent, recurrent tone based on one of the data settings. This is used for aural monitoring of data. For instance, if you are trying to combat global warming, you could set the tone monitor to report on air temperature. Every so often you will hear a tone. The higher the tone, the higher the average global temperature. You will hear the changes in temperature without having to look at the air temperature map.

PLAY DATA SONG is an option that is more fun than useful. It takes 32 evenly spaced samples of the selected data from the top to the bottom of the map, averages the values across the map, and plays them as notes. For example, if air temperature is selected, then the data song will convert the 32 data samples into 32 notes—the higher the air temperature, the higher the pitch. The notes will be lowest around the poles and highest near the equator.

ALTITUDE bases the sound on data in the Altitude array.

AIR TEMPERATURE bases the sound on data in the Air Temperature array.

RAINFALL bases the sound on data in the Rainfall array.

SEA TEMPERATURE bases the sound on data in the Sea Temperature array.

BIOMASS bases the sound on data in the Biome array.

LIFE bases the sound on data in the Life array.

CIVILIZATION bases the sound on data in the Humans array.

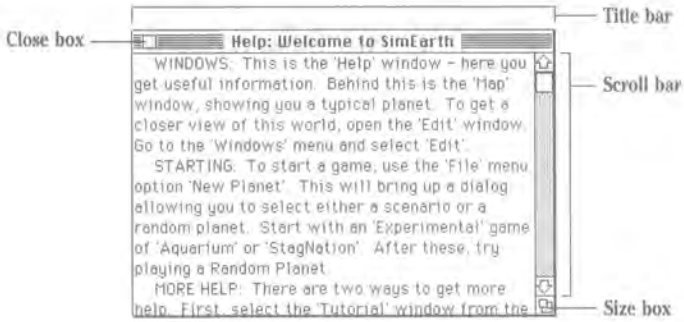
WINDOWS

HELP WINDOW

There are many different windows in SimEarth. Here is a complete description of each one.

There is on-screen help available for almost everything in SimEarth, including all menus, buttons, icons, tools, graphs, and control panels.

Help windows are not available through the menus. To get HELP, press and hold the SHIFT KEY. This will change your cursor to HELP MODE. Then click on any item on the screen, and you will be shown a text window with lots of information about that item.


Title bar
Close box
Help: Welcome to SimEarth
WINDOWS: This is the 'Help' window - here you get useful information. Behind this is the 'Map' window, showing you a typical planet. To get a closer view of this world, open the 'Edit' window. Go to the 'Windows' menu and select 'Edit'.
STARTING: To start a game, use the 'File' menu option 'New Planet'. This will bring up a dialog allowing you to select either a scenario or a random planet. Start with an 'Experimental' game of 'Aquarium' or 'StagNation'. After these, try playing a Random Planet.
MORE HELP: There are two ways to get more help. First, select the 'Tutorial' window from the
Scroll bar
Size box

If you ask for HELP in the DISPLAY AREA of the EDIT WINDOW, you will get the same information window that is produced by the EXAMINE icon.

If you ask for HELP in the DISPLAY AREA of the MAP WINDOW, you will get information on the active MAP WINDOW display.

There is a massive amount of information available in the HELP WINDOW. Almost anything in the world (simulated, that is) that you want to know about is in there.

The HELP WINDOW is your friend. Use it.

The on-line GLOSSARY is useful for getting help with definitions of words in the program you may not be familiar with. The GLOSSARY is available in the WINDOWS MENU.

NEW PLANET WINDOW

This is really a dialog box, not a window, but it is so important that for the purposes of this manual, we are giving it a promotion.

Use this window for creating new, random planets, and for starting the scenarios.

Experimental Mode
Easy Game : Energy - 5000
Average Game : Energy - 2000
Hard Game : Energy - 2000 / Gaia Unregulated
Cancel
Random Planet : Create your own World
EARTH : Modern Day 1990
AQUARIUM : Build Continents for a World in Stasis
MARS : Terraforming Greening the Red Planet
Stag Nation : Help Civilization out of the Stone Age
VENUS : Terraforming The Ultimate Challenge
EARTH : The Cambrian Era , 550 Million Years Ago
Daisy-World : Exploring the Gaia Hypothesis

At the top of the window are settings that let you choose the difficulty of the game or scenario. At the bottom of the window are the scenarios and random planet buttons.

Any random planet or scenario can be played in Experimental Mode, Easy Game, Average Game, or Hard Game.

Help is available on every setting and button in this window. Hold down the SHIFT KEY and click on anything in the window to receive help. You can get explanations of all the options and scenarios before beginning a game.

SETTINGS

Use these settings to adjust difficulty levels for all games, scenarios, random planets, and experiments. Just click on the button next to a setting to choose it.

EXPERIMENTAL MODE allows you to load any of the scenarios or a random planet and have unlimited energy for planet manipulation. With the unlimited energy, you can set up any type of planet you want in any stage of development, and add any other factors or conditions you want. This mode is really a "planetary spreadsheet."

This is also a good mode for learning SimEarth.

The MODEL CONTROL PANELS will all be randomly set at "moderate" values that should allow planetary progress without many changes.

EASY GAME is good for beginners. In an easy game, life appears and evolves quickly and easily. In fact, it will take some effort on your part to stop it.

Your starting energy level is 5000 E.U. (energy units)

The MODEL CONTROL PANELS will all be randomly set at "moderate" values.

AVERAGE GAME is a little more challenging. It will take some effort on your part to get your planet progressing and keep it going.

Your starting energy level is 2000 E.U.

The MODEL CONTROL PANELS will all be randomly set at "extreme" values that will require some fine tuning.

HARD GAME is really difficult. In fact, it's really very difficult. Not only will you have to adjust the MODEL CONTROL PANELS, but you will have to take on the role of Gaia.

The MODEL CONTROL PANELS will all be randomly set at "extreme" values that will require some fine tuning.

All Gaian regulation of climate, atmosphere and life is turned off and there will be no spontaneous generation of life—it's all in your hands.

CANCEL removes the NEW PLANET WINDOW in case you change your mind.

PLANETS AND SCENARIOS

Any planet or scenario can be played in Easy, Medium, or Hard Game as well as Experimental Mode. For in-depth descriptions of the scenarios see the "Scenarios" chapter of this manual. Just click on one of the planets to choose it.

RANDOM PLANET creates a randomly generated planet in any of the four Time Scales. When you choose this option, you will be shown a dialog box that will let you pick the Time Scale and name the planet.

AQUARIUM is a planet with no continents. It is a good starting point for those who like to design their own landmasses. It is in the Evolution Time Scale.

STAG NATION is a planet in the early Civilization Time Scale. Sentient life on this planet is limited to one small island. You can help it spread, or eliminate it and try to bring another life-form to intelligence.

EARTH CAMBRIAN ERA is a simulation of Earth in the Evolution Time Scale. One of the best features of this scenario is that its continental drift recreates the real Earth's drift.

EARTH MODERN DAY gives you a chance to take over the Earth of today. You'll get to deal with all the problems we deal with in the real world. This scenario is not recommended for escapists.

MARS gives you the chance to terraform Mars and turn it into a planet capable of supporting Earth life-forms.

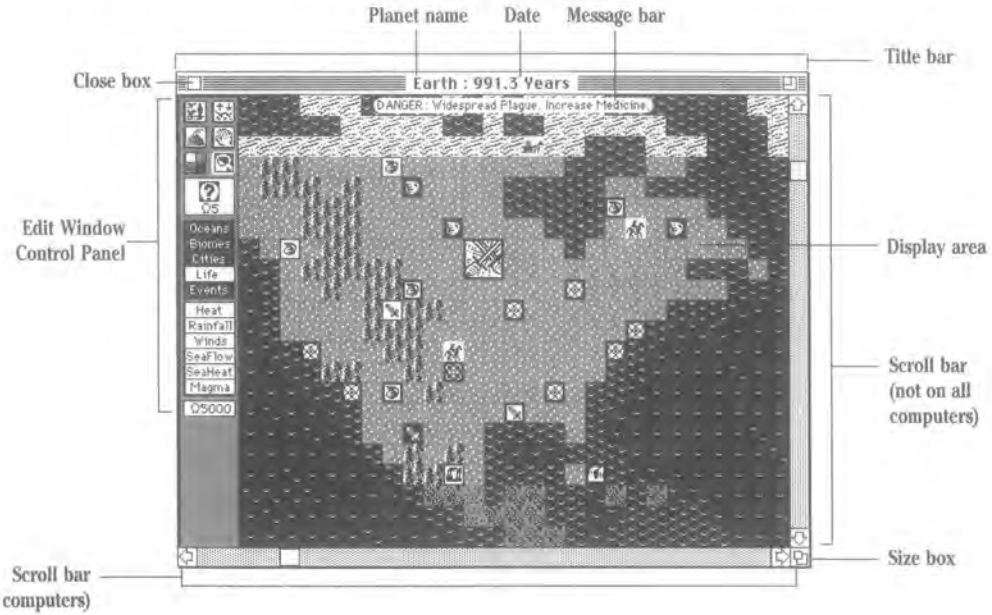
VENUS gives you the ultimate challenge in terraforming.

DAISYWORLD is the original, simpler version of the SimEarth simulation. Daisyworld was originally devised by James Lovelock as a demonstration of the Gaia theory.

EDIT WINDOW

The EDIT WINDOW is a close-up view of your planet. It is used for LOCAL INPUT—making changes to the planet, and for OUTPUT—investigating the planet and seeing the results of your input.

The EDIT WINDOW consists of four major parts: the TITLE BAR, the DISPLAY AREA, the SCROLL BARS, and the EDIT WINDOW CONTROL PANEL.



TITLE BAR

Located at the top of the EDIT WINDOW, the TITLE BAR displays the name of your planet and the date. The date can displayed as either the RELATIVE date or the ABSOLUTE date, selected from the SPEED MENU.

On the left side of the TITLE BAR is the CLOSE BOX. Clicking in this box will close the EDIT WINDOW. The window can be reopened by selecting the item "EDIT" from the WINDOWS MENU.

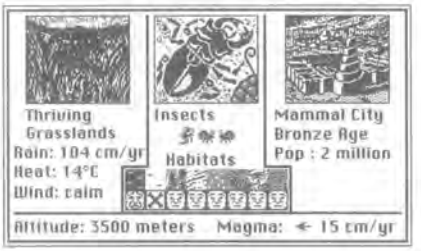
On the right side of the TITLE BAR is the GROW BOX. Clicking in this box will make the EDIT WINDOW grow until it fills the entire screen. Clicking it again will return the window to its former size.

The EDIT WINDOW can be moved around the screen by clicking and dragging the TITLE BAR.

EDIT WINDOW DISPLAY AREA

This is where you are shown your planet in a close-up view. The information you are shown here is controlled by the EDIT WINDOW CONTROL PANEL.

There are two scales that can be shown in this display: Normal and Compressed. If you select "Compress Edit Screen" from the OPTIONS MENU, this window will only display every other tile. This will give you less exact information, but will show you four times as much of the area of your planet as the Normal view. This is especially useful on machines with small screens (Mac Plus, SE, SE/30). This is the view that prints out with the PRINT option on the FILE MENU.

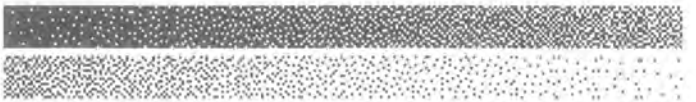


Using the HELP function (hold the SHIFT KEY and click) in the EDIT WINDOW DISPLAY AREA will bring up a window detailing all the information that the simulation has about the spot where you clicked.

Messages from the simulation and the SimEarthlings will sometimes appear at the top of the display area.

TERRAIN AND ELEVATION

There are 32 levels of terrain. The lighter the shade, the higher the altitude. Each different shade represents a change of 500 meters. Since altitude is measured from sea level, and sea level can be anywhere—or nowhere—there is no exact altitude that can be assigned to each shade.



There are three types of sea displays, depending on the depth of the water.

SHELF—0 to 1000 meters deep

OCEAN—1001 to 2500 meters deep

DEEP SEA—Greater than 2500 meters deep

SCROLLING THE TERRAIN

Depending on your computer, there may or may not be SCROLL BARS along the right and bottom of the EDIT WINDOW. If they are there, you can use them to scroll the terrain in the EDIT WINDOW to see different parts of the planet. Click on the arrows or the bars, or drag the scroll box to cause scrolling.

If there are no SCROLL BARS, then scrolling is accomplished by moving the pointer to any edge or corner of the screen. For keyboard-controlled scrolling, see the SimEarth addendum for your machine.

SIZE BOX

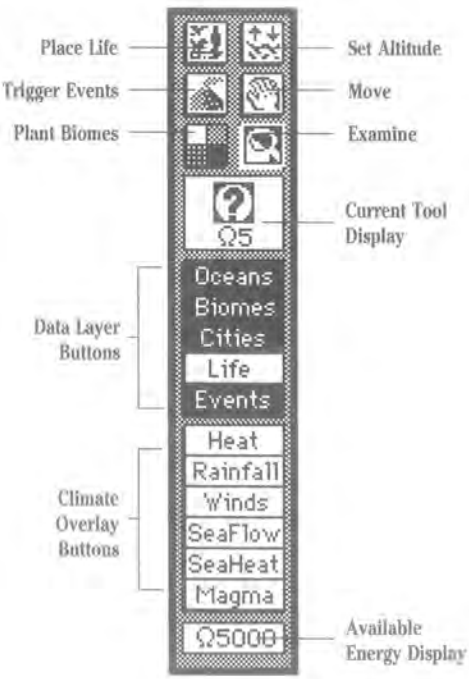
In the lower-right corner of the window is the SIZE BOX. Clicking and dragging this box will allow you to re-size the EDIT WINDOW.

EDIT WINDOW CONTROL PANEL

This control panel is for controlling both the information viewed in the EDIT WINDOW and for accessing the tools for planet modification.

Using the HELP function (hold the SHIFT KEY and click) in the CONTROL PANEL will bring up a small window with information about each of the items and buttons.

There are four sections to the EDIT WINDOW CONTROL PANEL: the TOOL ICONS, the CURRENT TOOL DISPLAY, the DATA LAYER BUTTONS, and the CLIMATE OVERLAY BUTTONS.



TOOL ICONS

By clicking on these icons, you access the tools for modifying your planet. There are six icons, three of which have submenus. Just below the Tool Icons is a box displaying the active icon and giving budget information for using that tool.

Every time you use one of the TOOL ICONS it will deplete your precious energy stores.

PLACE LIFE allows you to choose and place life and cities on the planet. This icon also allows you access to various terraforming tools for use on Mars and Venus.

Use this tool to spread life on the planet, to set various life-forms in competition with each other, and to test living conditions for various life-forms.

To select a life-form, city, or terraformer, click and hold on the PLACE LIFE icon. A submenu will appear. While holding the mouse button down, move the pointer to highlight the life, city, or terraformer of your choice, and then release the button.

Your choice will appear in the CURRENT TOOL DISPLAY, just below the icons, along with the cost in energy to place or use it.

To place the life, city, or terraformer on the planet, point to a spot in the display area and click.

There are 15 classes of life in SimEarth, seven in the sea, and eight on land. Each class of life is represented in SimEarth by 16 species.

Only 14 of the classes of life are available in the PLACE LIFE tool. CARNIFERNS—mobile, carnivorous plants that can develop intelligence—will sometimes evolve, but cannot be placed.

There are seven types of cities, each representing a level of civilization and technology. Most levels of technology are represented by cities with three population densities. Each of these levels also has a travelling population that represents sentients moving around, as well as trade and communication. The exception to this is the Nanotech Age, which is the highest level of technology in SimEarth. It has four levels of density, and no travelling population: we assume that they have matter transporters for instantaneous moving of people and products.

There are seven terraformers.

A complete description of the 15 classes of life in SimEarth is found later in this manual, in the chapter "Life." A complete description of the cities is covered in the chapter "Civilization." The terraformers will be covered in detail here.

The classes of life and cities available to place, with their cost in energy, are:

SEA LIFE CLASSES

PROKARYOTE—Single-celled life with no nucleus (bacteria). 35 E.U.

EUKARYOTE—Single-celled life with nucleus (amebas). 70 E.U.

RADIATE—Simple multi-celled life (starfish). 105 E.U.

ARTHROPOD—Crabs, lobsters, and crayfish. 140 E.U.

MOLLUSK—Snails, clams, oysters, scallops, octopi, and squid. 175 E.U.

FISH—Fish. 210 E.U.

CETACEAN—Whales and dolphins. 245 E.U.

LAND LIFE CLASSES

TRICHORDATE—Simple animal with a three-chord spine. 280 E.U.

INSECT—You know what these are. 315 E.U.

AMPHIBIAN—Frogs, newts, and toads. 350 E.U.

REPTILE—lizards, snakes, and turtles. 385 E.U.

DINOSAUR—Great big, huge reptiles. 420 E.U.

AVIAN—Birds. 455 E.U.

MAMMAL—Humans, apes, rodents, dogs, cats, etc. 490 E.U.

CITIES

The dates mentioned below are for reference to Earth only, and do not necessarily correspond with dates in SimEarth.

STONE AGE—Oldest Human culture; used stone tools. 500 E.U.

BRONZE AGE—Began circa 3500 B.C.; used bronze tools. 1000 E.U.

IRON AGE—Began circa 1000 B.C.; used iron tools. 1500 E.U.

INDUSTRIAL AGE—Began in late 18th century with the use of powered machinery. 2000 E.U.

ATOMIC AGE—Began in the 1950s with the use of atomic power. 2500 E.U.

INFORMATION AGE—Begins circa 2000 A.D.—information is the most important tool. 3000 E.U.

NANOTECH AGE—Begins sometime in the future, characterized by science and technology beyond our imagination. 3500 E.U.

TERRAFORMERS

Terraformers are tools for turning Venus and Mars into earth-like planets. They aren't needed on Earth, or planets that are earth-like to begin with, but go ahead and try them to see what happens. Once placed, Terraformers keep working. Don't place too many—the only way to stop one is to hit it with a Meteor, Fire, or a Volcano.

BIOME FACTORY—When terraforming Mars or Venus, place the Biome Factory instead of individual biomes. The Biome Factory, once placed, looks at the terrain and climate and starts producing the appropriate biome type that can survive there. It will also detect changes in climate, and change the biomes it produces to a type that will survive the changes. Biome Factories cost 500 E.U.

OXYGENATOR—The Oxygenator takes carbon dioxide (CO_2) out of the atmosphere and spits out free oxygen. Life requires a certain percentage of oxygen, between 15 to 25%, to survive. Too much oxygen on a planet will cause fires. Since it lessens the CO_2, a greenhouse gas, the Oxygenator will help cool a hot planet. An Oxygenator costs 500 E.U.

N_2 GENERATOR—The N_2 (nitrogen) Generator is used to increase atmospheric pressure on a planet. The atmospheric density affects the planet's temperature—a denser atmosphere allows the planet to retain more heat. The thinner the atmosphere, the colder the planet. Also, having a denser atmosphere with lots of N_2 stabilizes the percentages of the other gases. An N_2 Generator costs 500 E.U.

VAPORATOR—The Vaporator spews water vapor into the atmosphere, raising the overall humidity of the planet and increasing rainfall. A Vaporator costs 500 E.U.

CO_2 GENERATOR—The CO_2 Generator produces CO_2, which is necessary for plants to live. A CO_2 Generator costs 500 E.U.

MONOLITH—The Monolith isn't a Terraformer, but we didn't have anywhere else to put it in the program. It is an Evolution Speed-up Device (our thanks to Arthur C. Clark).

To use it, select the Monolith, then immediately click on a life-form. There is a one-in-three chance of that life-form suddenly mutating to a higher level, which immediately moves you to the next Time Scale. It costs 2500 E.U. to use a Monolith—whether or not it works.

The Monolith can't be used on all life-forms—if you try to use the Monolith on a life-form that cannot mutate, the program will beep at you, but there will be no energy charge.

A disadvantage to using the Monolith is that you could jump ahead into the civilization Time Scale before enough fossil fuels have been generated, and civilization will collapse. Also, you need a wide population base to advance to the next technology level. Don't rush to a new Time Scale at the expense of your population.

If you successfully use the Monolith in the Technology Time Scale, it will bring about the Exodus event.

ICE METEOR—The Ice Meteor is a huge chunk of ice that you can crash into a dry planet to add water to the planetary system. An Ice Meteor costs 500 E.U.

THE EXTINCT FUNCTION

An added feature of the PLACE LIFE tool is the EXTINCT FUNCTION. If you want to remove a particular class of life from the planet, hold down either the OPTION KEY or CONTROL KEY (depending on your machine), then click on the PLACE LIFE icon and select a life-form from the PLACE LIFE submenu. All occurrences of the life-form you chose will disappear.

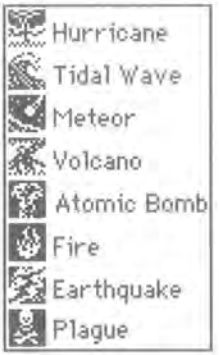
The EXTINCT FUNCTION only works on life-forms—not on cities. If you want to eliminate a life-form, you must do it before it reaches sentience and builds cities.

EVENT TRIGGER

The EVENT TRIGGER lets you select and activate various events at various places on your planet.

The simulation will cause events to occur automatically, depending on many factors including the age of the planet, the climate, air and water temperatures, and sea level.

There are 11 possible events that occur in SimEarth. Three of them, exodus, war and pollution, will occur, but cannot be triggered by the user.



By triggering events yourself, you can learn the effects these events have on local populations as well as to the planet as a whole.

To activate events, click and hold on the EVENT TRIGGER icon. A submenu will appear, giving you a choice of eight events. While the mouse button is still down, slide the pointer to the right so it highlights the event you want to place, and release the button.

The selected event will appear in the CURRENT TOOL DISPLAY, just below the icons, along with the cost in energy to trigger it.

Next, move the pointer to the DISPLAY AREA, and click the mouse button to trigger an event on your planet. Click again in another place to cause the same event.

A complete description of all events and their causes and effects will be covered in the chapter "Events."

The available events in SimEarth, and their cost in energy, are:

HURRICANE—High winds and rain. 50 E.U.

TIDAL WAVE—A huge, destructive ocean wave. 50 E.U.

METEOR—A huge rock from space that crashes into your planet. 50 E.U.

VOLCANO—An explosive leak in the planet's surface that spews molten rock. 50 E.U.

ATOMIC TEST—An atomic explosion. 50 E.U.

FIRE—Hot stuff. 50 E.U.

EARTHQUAKE—Shake, rattle and roll. 50 E.U. Clicking and holding on the Earthquake icon brings up a submenu that allows you to direct the Earthquake's energies.

PLAGUE—A deadly disease. 50 E.U.

PLANT BIOME—allows you to place or plant biomes onto your planet.

A biome is a major ecological community of plants and animals. Biomes will automatically be placed on the planet by the simulation. Their quantity and location is primarily controlled by altitude, temperature, and rainfall.

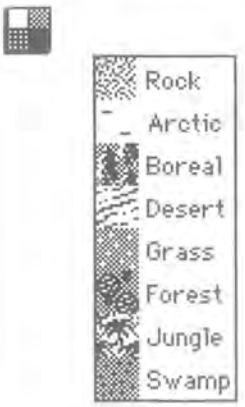
With this tool you can place any of the biomes anywhere on the planet at any time. Of course, they won't necessarily stay there. An Arctic biome will not last long in the hot equatorial zone, and a Jungle will not thrive at a planet's pole.

Place biomes to experiment, and to help shape or speed up development on your planet.

To use this tool, click and hold on the PLANT BIOME icon. A submenu will appear, giving you a choice of eight biomes. While the mouse button is still down, slide the pointer to the right so it highlights the biome you want to plant, and release the button. The selected biome will appear in the CURRENT TOOL DISPLAY, just below the icons, along with the cost in energy to place it. There is an energy cost of 50 E.U. for each biome planted.

Next, move the pointer to the DISPLAY AREA, and click the mouse button to place a biome on your planet. The button can be held down while the mouse is slowly moved to place multiple segments. A click will be heard as each BIOME is placed. The pitch of the click will raise and lower with the terrain altitude.

A complete description of all the biomes in SimEarth will be found later in this manual in the chapter "Life." There are seven available biomes in SimEarth, plus ROCK, which represents a lack of a biome in a location.



BIOMES

ROCK—No biome.

ARCTIC—Can survive in a cold and dry climate.

BOREAL FOREST—Can survive in cold temperatures, with moderate to high rainfall.

DESERT—Can survive in moderate to hot temperatures, with very little rainfall.

TEMPERATE GRASSLANDS—Can survive in areas with moderate temperatures and rainfall.

FOREST—Can survive with moderate temperatures and high rainfall.

JUNGLE—Can survive with high temperatures and rainfall.

SWAMP—Can survive with high temperatures and moderate rainfall.

BIOME PREFERENCE CHART

	DRY (<30 cm/yr)	MODERATE (30–90 cm/yr)	WET (>90 cm/yr)
COLD (<0° C)	Arctic	Boreal Forest	Boreal Forest
MODERATE (0–25° C)	Desert	Temp. Grasslands	Forest
HOT (>25° C)	Desert	Swamp	Jungle

Biome preferences are also influenced by altitude and the amount of CO_2 in the atmosphere.

SET ALTITUDE allows you to raise or lower sections of land. There are 32 possible levels of terrain in SimEarth.

Use this tool to raise or level mountain ranges, create islands in the ocean, or lakes in dry land. All these changes will have impact on climate, rainfall, local biomes, and local life-forms.

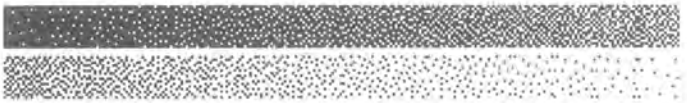
Click on the SET ALTITUDE icon. Look at the CURRENT TOOL DISPLAY. It shows that the SET ALTITUDE tool is active in "raise terrain" mode.

Move the pointer to the DISPLAY AREA. Click and hold the mouse button over land or water, and the land around the pointer will be raised in altitude, displayed by a lightening of the color or shade of the land.

Click on the SET ALTITUDE icon again, and look at the CURRENT TOOL DISPLAY. It shows that the SET ALTITUDE tool is active in "lower terrain" mode.

Move the pointer to the DISPLAY AREA. Click and hold the mouse button over land, and the land around the pointer will be lowered in altitude, displayed by a darkening of the color or shade of the land.

Levels of terrain are displayed in shades. The lighter the shade, the higher the altitude. Each different shade represents a change of 500 meters. Since altitude is measured from sea level, and sea level can be anywhere—or nowhere—there is no exact altitude that can be assigned to each shade.



The cost for using the SET ALTITUDE tool to raise or lower the terrain is 50 E.U.

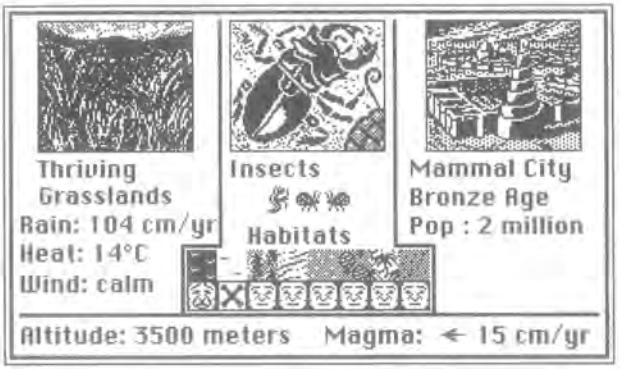
MOVING TOOL lets you pick any biome, niche, or civilization and move it. This can be useful for transplanting populations to other continents, or separating warring tribes. Since niches and biomes can occupy the same space in the display, you can use this tool to temporarily move the niche to see the biome that is displayed underneath it.

Click on the MOVING TOOL icon to activate it, then click and hold on a biome, niche or civilization. Drag the pointer to the destination location, and release the mouse button.

The cost for using the MOVING TOOL is 30 E.U.

EXAMINE gives you information on individual spots in the DISPLAY AREA.

Click on the EXAMINE icon, and the mouse pointer changes to a magnifying glass. Then click and hold on a spot in the DISPLAY AREA. An information window will appear, giving you all the information that the simulation has about that spot.



If you click and hold the button, and slowly drag the pointer across the screen, the information window will change and report on each section as you point to it.

The EXAMINE function is very useful for gathering information about specific areas of your planet. You will need this information for planning your next moves in planet development.

The same information window can be accessed by using the HELP function (hold the SHIFT KEY or HELP KEY while clicking on a spot) in the DISPLAY AREA.

The EXAMINE tool only gives information on places in the display window. For information on icons and tools, use the HELP function.

The cost for using the EXAMINE tool is 5 E.U.

There are four sections to the EXAMINE WINDOW: the Biome Section, the Life Section, the City Section, and the Altitude/Magma Section.

BIOME SECTION
The Biome Section shows a picture of the local biome (if any), and a description of its present condition, i.e., thriving, dying, etc. Next, it displays the rainfall, air temperature (heat), and wind direction.

If there is no biome present, this section will display the message "No Biome."

LIFE SECTION
If there is life, the Life Section shows a big picture of the predominant class of non-sentient life in that location. (Sentient life is treated separately in the City Section.) Below that are three small pictures. The middle one is the present species of the class, the left one is the species that it evolved from, and the right one is the species that, if all goes well, it will evolve into.

Below that is a chart of how that life class gets along in the various habitats, with a picture rating of how happy the species are there:

Can't live there.

Can survive there, but it's miserable.

Can survive there, and quite nicely.

Paradise.

If there is no life, this section will display the message "No Life."

CITY SECTION

If there are no sapients near, this section will display the message "No Sapients."

If there are sapients, but no city, this section will display the message "Lightly Inhabited."

If there is a city, this section displays a large picture of the city, and tells the sapient class, the technology level, and the population.

ALTITUDE/MAGMA SECTION

This section, at the bottom of the window, displays this location's altitude and direction of magma flow.

CURRENT TOOL DISPLAY

The CURRENT TOOL DISPLAY shows the active icon, tool, life-form, biome, terraformer, or event, and the energy cost to use it.

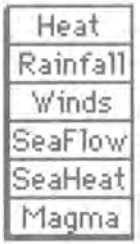
DATA LAYER BUTTONS

These buttons control what data is displayed in the DISPLAY AREA. By clicking on these buttons, you toggle on and off the various layers of data. Using these buttons does not change the planet, or affect the model in any way—it only changes your view of the planet.

The default settings for these buttons changes with the Time Scale. In the Geologic Time Scale, the default setting has everything on except BIOMES and CITIES. In the Evolution Time Scale, everything is on except CITIES. In both the Civilization and Technology Time Scales, everything but LIFE defaults to the "on" setting.

OCEANS allows you to turn off and on the display of the Oceans, allowing you to see the elevation of the sea bottom.
BIOMES allows you to turn off and on the display of Biomes, so you can see the elevation of the terrain, and see Life and Cities more clearly.
CITIES allows you to turn off and on the display of the Cities of the current sentient species.
LIFE allows you to turn off and on the display of life-forms. Since these are so numerous and fast-moving, you may want to turn these off every so often to get a clearer view of the other things on your planet. This display is of individual species, not classes—there are 240 different species in SimEarth.
EVENTS allows you to turn off and on the display of Events.

CLIMATE OVERLAY BUTTONS



These buttons also control what data is displayed in the DISPLAY AREA. By clicking on these buttons, you toggle on and off the various layers of climate data. Using these buttons does not change the planet, or affect the model in any way—it only changes your view of the planet.

The default setting for all these buttons is OFF. Only one climate overlay can be active at any one time.

HEAT—A display of air temperature. Higher temperatures are represented by darker shades.
RAINFALL—A display of average rainfall. Higher rainfall densities are represented by darker shades.
WINDS—A display of the wind currents.
SEA FLOW—A display of the sea currents.
SEA HEAT—A display of water temperature. Higher temperatures are represented by darker shades.
MAGMA—A display of the magma currents under the planet's crust.

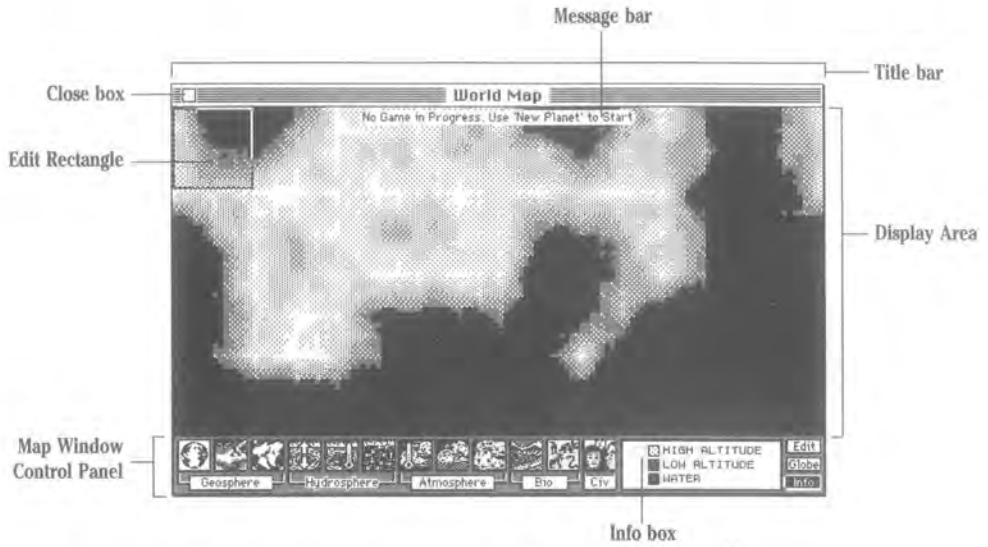
AVAILABLE ENERGY DISPLAY

This display lets you know how much energy you have left for planet manipulation and modification. The maximum energy that can be stored is set by the game level.

For a complete explanation, see the chapter "Energy."

MAP WINDOW

The MAP WINDOW is your overview of the whole planet. It can be viewed as a flat or spherical projection.



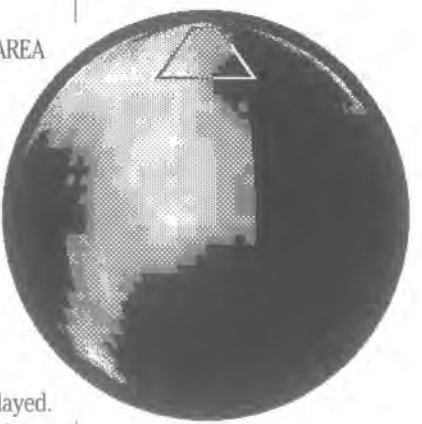
The MAP WINDOW consists of three major parts: the TITLE BAR, the MAP DISPLAY AREA, and the CONTROL PANEL.

TITLE BAR

The TITLE BAR displays the type of map being shown in the MAP DISPLAY AREA and the date.

On the left side of the TITLE BAR is the CLOSE BOX. Clicking in this box will close the MAP WINDOW. You can bring the window back by selecting the MAP item in the WINDOWS MENU.

The MAP WINDOW can be moved on the screen by clicking and holding in the TITLE BAR, and dragging the window to its new location.



MAP WINDOW DISPLAY AREA

The MAP WINDOW DISPLAY AREA is where the map of the planet is displayed. There are many different types of displays and views of your planet, which are selected in the MAP WINDOW CONTROL PANEL.

In the MAP DISPLAY AREA you will see the EDIT RECTANGLE. This rectangle indicates the area of the world that is visible in the EDIT WINDOW. If you double-click in the EDIT RECTANGLE, the EDIT WINDOW will be brought to the front.

Messages from the simulation and the SimEarthlings sometimes appear at the top of the MAP DISPLAY AREA.

MAP WINDOW CONTROL PANEL

The MAP WINDOW CONTROL PANEL allows you to look at various views of your planet, giving different types of information in each view. From here you can also access all of the MODEL CONTROL PANELS, the HISTORY WINDOW, the EDIT WINDOW, and all the GRAPHS.

MAP DISPLAY ICONS

Along the top of the MAP WINDOW CONTROL PANEL, from the left, are 12 icons. Clicking on each of these icons displays different information in the MAP DISPLAY AREA. These 12 displays are divided into five groups: GEOSPHERE, HYDROSPHERE, ATMOSPHERE, BIO(SPHERE) and CIV(ILIZATION). A MODEL CONTROL PANEL can be accessed for four of the five groups (excluding HYDROSPHERE) by clicking on the name of that group.

GEOSPHERE GROUP

The GEOSPHERE group gives information on the terrain, events and magma flow of the planet. Clicking on the GEOSPHERE icon brings up the GEOSPHERE MODEL CONTROL PANEL.

TERRAIN MAP shows oceans and altitude across the planet. Higher altitudes are shown in lighter shades, lower altitudes are darker. Water is shown as either blue or black, depending on your monitor.

A legend of the altitude is visible in the INFO BOX near the right side of the MAP WINDOW CONTROL PANEL.

An extra feature accessed through this icon is a display of landmarks on the scenario planets. Click and hold on the icon, and names of landmarks will be

displayed until you release the mouse button. This is available only on scenario planets. Random planets have no landmarks. Landmarks on Earth will stop being displayed 2,000,000 years in the future. We figure the names will change by then.

Double-clicking in this icon will open the GAIA WINDOW.

GLOBAL EVENT MAP shows global events, such as hurricanes, forest fires, earthquakes, meteorites, wars, etc., as small symbols.

A key to the symbols is visible in the INFO BOX near the right of the CONTROL PANEL.

CONTINENTAL DRIFT MAP shows the currents within the magma layer. Magma is the hot molten rock within the earth, upon which the continental plates are "floating." The currents here determine the direction and speed of continental drift.

A legend of the magma current vectors is available for this map in the INFO BOX.

HYDROSPHERE GROUP

This group gives information on the ocean. There is no MODEL CONTROL PANEL for the Hydrosphere.

HIDE/SHOW OCEANS toggles the ocean display on and off so you can see the elevation of the ocean floor. This doesn't make the ocean go away—it just makes it invisible. This option is used in combination with other maps, and has no legend in the INFO BOX.

OCEAN TEMPERATURE displays the average annual ocean temperature. In most cases this will correspond closely with the air temperature, but it will change much more slowly.

The INFO BOX can display both a legend to the ocean temperatures and a graph of average ocean temperature over time. To switch between these two displays, click on the INFO BUTTON in the lower-right corner of the MAP WINDOW CONTROL PANEL.

OCEAN CURRENTS displays the surface currents of the oceans.

A legend of ocean current vectors is available for this map in the INFO BOX.

Atmosphere

ATMOSPHERE GROUP
This group displays information on the atmosphere and climate. Clicking on the ATMOSPHERE icon brings up the ATMOSPHERE MODEL CONTROL PANEL.

AIR TEMPERATURE displays the average annual air temperature. The heat displayed here comes primarily from the sun, and secondarily from warm ocean areas.

The INFO BOX can display both a legend of the air temperatures and a graph of average air temperature over time. To switch between these two displays, click on the INFO BUTTON in the lower-right corner of the MAP WINDOW CONTROL PANEL.

Double-clicking on this icon will open the ATMOSPHERIC COMPOSITION GRAPH.

RAINFALL displays the average yearly rainfall. The heaviest rainfall will usually be concentrated over the equator.

The INFO BOX can display both a legend for the rainfall map and a graph of average rainfall over time. To switch between these two displays, click on the INFO BUTTON in the lower-right corner of the MAP WINDOW CONTROL PANEL.

Double-clicking on this icon will open the ATMOSPHERIC COMPOSITION GRAPH.

AIR CURRENTS shows the average air currents. As with ocean currents, these are determined by thermal disequilibrium and Coriolis effect.

A key to the air current vectors is available in the INFO BOX.

Double-clicking on this icon will open the ATMOSPHERIC COMPOSITION GRAPH.

BIOSPHERE GROUP
This group gives information on the life on your planet. Clicking on the Biosphere icon brings up the BIOSPHERE MODEL CONTROL PANEL.

Bio

BIOMES displays the distribution of biomes on your planet.

The INFO BOX can display both a legend to biome distribution on the map and a graph of average biomass over time. To switch between these two displays, click on the INFO BUTTON in the lower-right corner of the MAP WINDOW CONTROL PANEL.

Double-clicking on this icon opens the BIOME RATIO GRAPH.

LIFE displays the diversity of life on your planet.

The INFO BOX can display both a legend to the life-forms and a graph of genetic diversity over time. To switch between these two displays, click on the INFO BUTTON in the lower-right corner of the MAP WINDOW CONTROL PANEL.

Double-clicking on this icon will open the LIFE CLASS RATIO GRAPH.

CIVILIZATION GROUP
This is where you will find worldwide information on civilizations on your planet. Clicking on the Civilization icon brings up the CIVILIZATION MODEL CONTROL PANEL.

Civ

CIVILIZATION shows the distribution of civilizations on the planet. More advanced civilizations will appear darker. Terraformers will be shown on this map in black.

The INFO BOX can display both a legend to the civilizations on the planet and a graph of the population of your sentient species over time. To switch between these two displays, click on the INFO BUTTON in the lower-right corner of the MAP WINDOW CONTROL PANEL.

Double-clicking on this icon will open the TECHNOLOGY RATIO GRAPH.

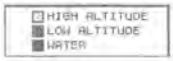
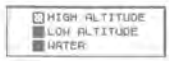
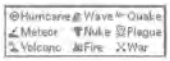
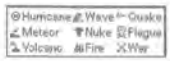
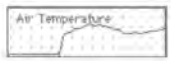
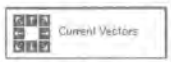
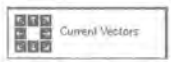
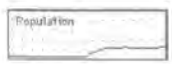
INFO BOX

The INFO BOX is located just to the right of the Civilization icon.

This box displays helpful information about the map view: legends to help interpret the map, and graphs of the information displayed in the map shown over time. These graphs correspond with the graphs in the HISTORY WINDOW.

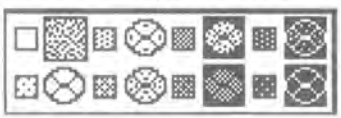
You can bring up the HISTORY WINDOW by double-clicking inside the INFO BOX.

Some map views have map legends to be displayed here, others have both legends and graphs. HIDE/SHOW OCEANS has neither. Toggle between info sets by clicking on the INFO BUTTON in the lower-right corner of the MAP WINDOW.

ACTIVE MAP ICON	INFO BUTTON HIGHLIGHTED	INFO BUTTON NOT HIGHLIGHTED
TERRAIN MAP		
GLOBAL EVENTS*	 *	 *
CONTINENTAL DRIFT		
HIDE/SHOW OCEANS	N/A	N/A
OCEAN TEMP		
OCEAN CURRENTS		
AIR TEMPERATURE		
RAINFALL		
AIR CURRENTS		
BIOMES		
LIFE		
CIVILIZATION		

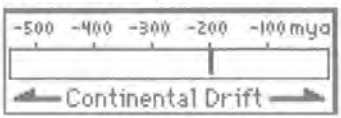
* Note: Two Events, Pollution and Exodus, are not included in the Event Map legend, but will appear on the map when they occur.

DAISYWORLD INFO DISPLAY



When in the Daisyworld Scenario, in the Biome view, the highlighted INFO BOX displays the distribution of the different shades of daisies.

CONTINENTAL DRIFT RECORD



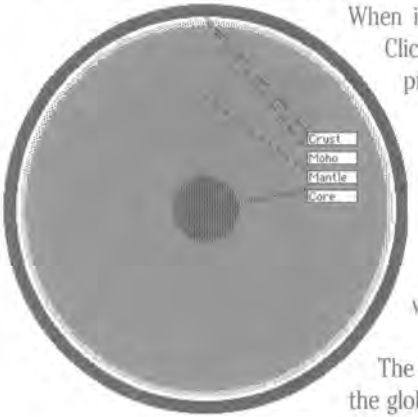
If you click and hold on the INFO BOX (regardless of the status of the INFO BUTTON) and slowly move the mouse back and forth, you will be shown an animated history of continental drift on your planet.

BUTTONS

There are three buttons on the far right side of the MAP CONTROL PANEL.

EDIT brings the EDIT WINDOW to the front.

GLOBE changes the MAP WINDOW view from a flat robinson projection to a spherically mapped globe projection. All maps and displays are available in GLOBE mode—the MAP WINDOW CONTROL PANEL doesn't change. When in this mode, the GLOBE BUTTON will be highlighted. Clicking on the GLOBE BUTTON again will return you to the flat projection.



The EDIT RECTANGLE becomes an EDIT TRAPEZOID on the GLOBE. If you double-click in the EDIT TRAPEZOID, the EDIT WINDOW will be brought to the front.

Clicking, holding, and dragging the outer rim of the globe will allow you to move it on the screen.

The interior of the globe can be viewed by double-clicking on the globe, anywhere but in the EDIT TRAPEZOID. Click again to return to the surface of the planet.

INFO toggles between different information views in the INFO BOX.

ACCESSING MODEL CONTROL PANELS

The MODEL CONTROL PANELS are available through the MODELS MENU, but they can also be accessed by clicking on the icons GEOSPHERE, ATMOSPHERE, BIOSPHERE, and CIVILIZATION on the MAP CONTROL PANEL.

ACCESSING GRAPHS

All graphs can be accessed both through the GRAPHS MENU and the MAP CONTROL PANEL. They are opened by double-clicking on various icons in the MAP CONTROL PANEL.

The ATMOSPHERIC COMPOSITION GRAPH is opened by double-clicking on any of the three ATMOSPHERE icons.

The BIOME RATIO GRAPH is opened by double-clicking on the BIOMES icon.

The LIFE CLASS RATIO GRAPH is opened by double-clicking on the LIFE icon.

The TECHNOLOGY RATIO GRAPH is opened by double-clicking on the CIVILIZATION icon.

ACCESSING OTHER WINDOWS

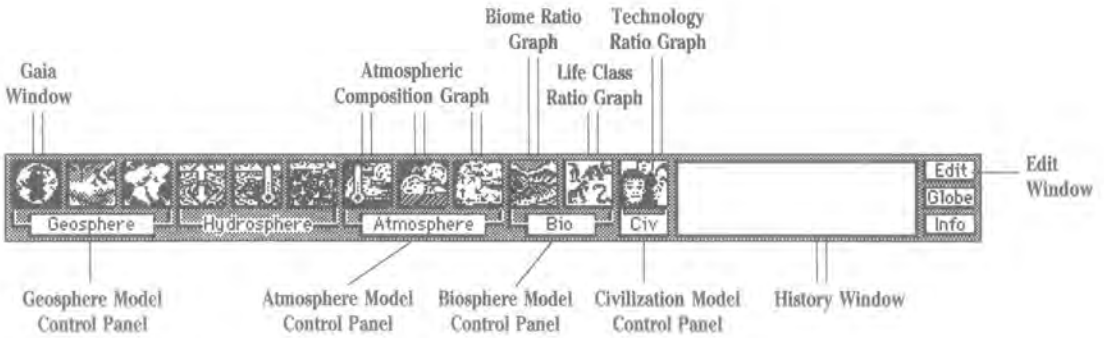
Double-click in the INFO BOX to open the HISTORY WINDOW.

Double-click on the TERRAIN MAP icon to open the GAIA WINDOW.

ACCESS TO GRAPHS AND WINDOWS FROM MAP WINDOW CONTROL PANEL

—— A single line represents a single click.

═══ A double line represents a double-click.



GAIA WINDOW

The GAIA WINDOW shows Gaia, a caricature of the Earth as one living organism. This "face of the planet" will give you constant feedback on the planet's "mood."

This window can be opened by selecting GAIA from the WINDOWS MENU, or by double-clicking on the TERRAIN MAP icon in the MAP WINDOW.

The planet's mood is based on how well life on the planet is doing. The face will be asleep until life forms, then it will wake up. The moods range from bliss to horror. Everything that happens and everything you do affects the face.

At the bottom of this window is a little message bar that will display messages from Gaia. In the upper-right corner of the window is the Sun. As solar heat increases through time, the Sun will slowly begin to enlarge. At the end of your planet's 10-billion-year life, the Sun will burn up Gaia.

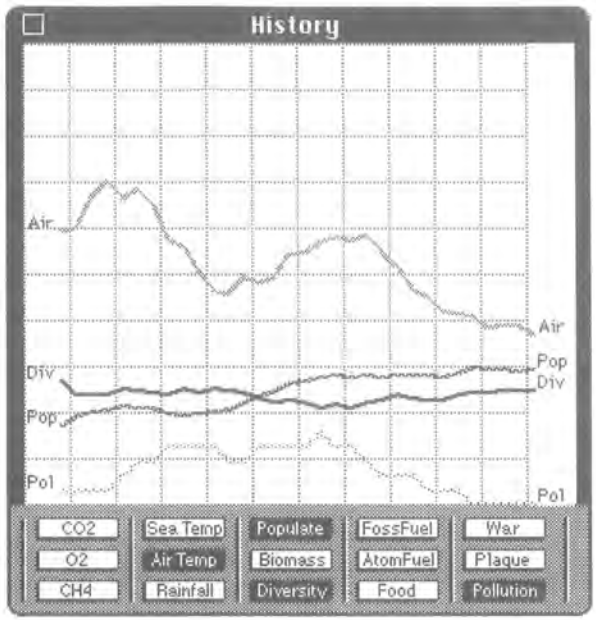
You may want to keep this window in a corner of the screen, and let it guide you as you develop your planet.

Its eyes will follow the pointer around the screen. Please don't poke it in the eye.

HISTORY WINDOW

The HISTORY WINDOW provides a graphical record of many factors that define your planet.

Use this window for tracking the changes and development of your planet's chemical composition, temperature, humidity, life, events, and pollution.



This window is accessed through the WINDOWS MENU, and by double-clicking on the INFO BOX in the MAP WINDOW CONTROL PANEL.

Click on any of the icons at the bottom of the window to toggle the display of that factor on and off.

There are 15 items that can be displayed as a graph in this window. Up to four items can be displayed at a time.

CO_2 displays Carbon Dioxide levels in the atmosphere.

O_2 displays Oxygen levels in the atmosphere.

CH_4 displays Methane levels in the atmosphere.

SEA TEMPERATURE displays overall average temperature of the oceans.

AIR TEMPERATURE displays overall average temperature of the atmosphere.

RAINFALL displays overall average planetary rainfall.

POPULATION displays population of the sentient species on your planet.

BIOMASS displays the total weight of all plant and animal matter on the planet. The biomass of Earth is 99% plant material.

DIVERSITY displays the number of different species of life on the planet. Major extinctions will be visible here.

FOSSIL FUELS displays the amount of fossil fuel reserves still within the planet. This amount grows during the Evolution Time Scale as biomass decays, and is depleted by civilization.

ATOMIC FUEL displays the amount of atomic fuel reserves within the planet.

FOOD displays the total amount of food produced on the planet.

WAR displays the level of armed conflict across the planet.

PLAGUE displays the number of plague events that have occurred.

POLLUTION displays the total amount of toxic releases by the sentient species.

To keep the planet data file at a reasonable size, a complete history is not saved with the planet. Once the graph goes off the left of the HISTORY WINDOW it is lost forever.

There will be a dividing line to mark when one Time Scale ends and another begins.

The amount of time displayed per division in this window is different for each of the Time Scales. The full width of the HISTORY WINDOW covers approximately:

1,000,000,000 years in the Geologic Time Scale;
70,000,000 years in the Evolution Time Scale;
2,500 years in the Civilization Time Scale; and
50 years in the Technology Time Scale.

REPORT WINDOW

The REPORT WINDOW is your main source of feedback on how well both you and life on your planet are doing. The information in the REPORT WINDOW changes for the various Time Scales, giving information that is useful for each era. There is also a special REPORT WINDOW for the Daisyworld Scenario.

REPORT WINDOW IN THE GEOLOGIC TIME SCALE

In this Time Scale, the REPORT WINDOW gives four items of information.

VIABILITY

This rating tells you how hospitable your world is to multi-celled animals. Viability is based on the oxygen and dust content of the atmosphere. The rating levels are:

Life cannot exist here.

Life can exist, but barely.

Life can exist fairly well.

Paradise.

BIOMASS

Biomass is the total weight of all plants and animals on the planet. In the Geologic Time Scale there are no plants, so the Biomass is formed entirely of Eukaryotes. The theoretical maximum value for Biomass in this Time Scale is 40,960.

HIGHEST LIFE

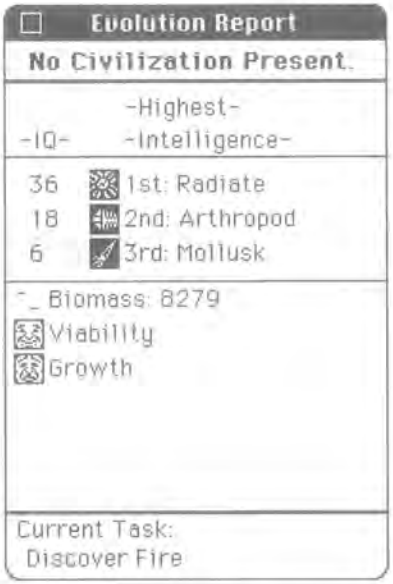
This is a display of the most advanced microbe life-form.

CURRENT TASK

Your CURRENT TASK is what needs to be accomplished before moving on to the next Time Scale.

REPORT WINDOW IN THE EVOLUTION TIME SCALE

In this Time Scale, the REPORT WINDOW gives a few more items of information.



INTELLIGENCE

This is a display of the "race to intelligence." The three most advanced forms of life are listed, and given an "intelligence" rating (IQ). This rating is just a rough estimate of how advanced the life-forms are and does not relate to human IQ levels.

This display show the leaders in the race to sentience. When a life-form reaches an IQ of 100, it becomes sentient.

BIOMASS

Biomass in the Evolution Time Scale consists of the combined mass of both the animal life and the biomes—plant life. Jungles are the richest, highest mass biomes, Deserts the poorest and lowest mass. The theoretical maximum value for biomass is 180,224.

The icon shown for Biomass is the predominant biome.

VIABILITY

This rating tells you how hospitable your world is to multi-celled animals. Viability is based on the oxygen and dust content of the atmosphere. The rating levels are the same as in the Geologic REPORT WINDOW.

GROWTH

The biomass requires CO_2 for survival and growth. The Growth rating is based on the CO_2 content of the atmosphere.

CURRENT TASK

Your CURRENT TASK is what needs to be accomplished before moving on to the next Time Scale.

REPORT WINDOW IN THE CIVILIZATION AND TECHNOLOGY TIME SCALES

In these Time Scales, you are given much more information.

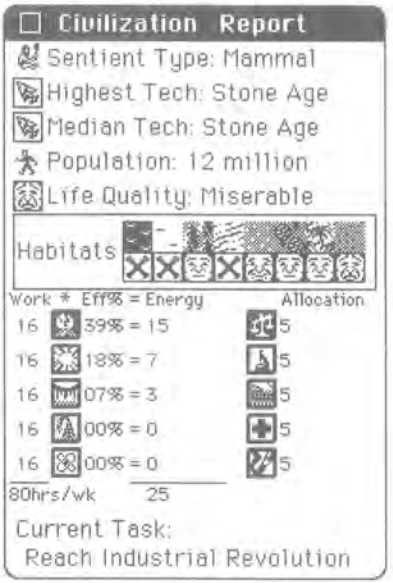
SENTIENT TYPE
This tells you what class of life is the dominant, intelligent species on your planet.

HIGHEST TECHNOLOGY tells you the highest level of civilization on your planet.

MEDIAN TECHNOLOGY tells you the average technology level of your planet.

POPULATION tells the current population of your planet's sentient species.

LIFE QUALITY gives an overall "quality of life" rating for the sentient species on your planet. The two factors taken into consideration in this rating are number of work hours per week, and your allocation of resources to Arts and Media. It is difficult to have a life quality above tolerable in lower technology levels.



The possible quality levels are: Heavenly, Marvelous, Good, Pleasant, Tolerable, Unpleasant, Bad, Miserable, and Hellish.

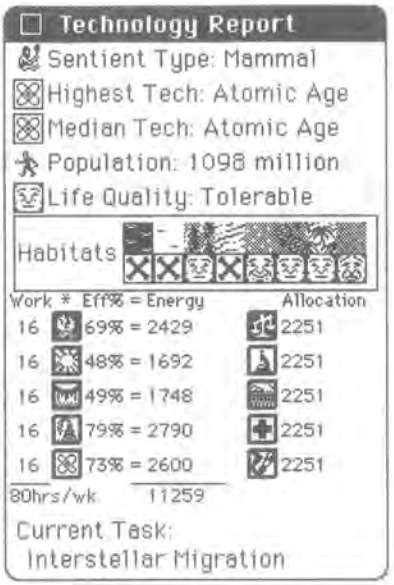
HABITATS shows the ability of your sentient species to survive in the various biomes, and how well they are adapted to the habitat. The rating levels are:

Can't live there at all.

Can live there, but hates it.

Can live there, and likes it.

Paradise.



ENERGY SECTION

Below the Habitats is a large section that deals with energy. To best understand what happens here, look at the REPORT WINDOW and the CIVILIZATION MODEL CONTROL PANEL side-by-side.

WORK is the amount of hours per week that your sentient SimEarthlings must work to survive. In SimEarth, we have simplified the concept of work: all work produces energy.

The amount of time intelligent SimEarthlings work is divided between five different energy sources. The amount of time worked to produce energy from each of the five sources is set on the left side of the CIVILIZATION MODEL CONTROL PANEL. The total number of hours worked per week affects the quality of life.

TYPES OF ENERGY

BIOENERGY—Burning wood, animal power, plant power (farming), work done by hand by the sentient species.

SOLAR/WIND—Sun-drying of food and clothes, windmills, sailing ships, solar heating, wind-powered generators, solar electric cells, satellites collecting solar energy.

HYDRO/GEO—Waterwheels, dams, steam power, hydroelectric power, geothermal power.

FOSSIL FUEL—Coal and oil made from long-dead animals.

NUCLEAR—Atomic power plants.

EFFICIENCY is a rating of how much energy you receive for the amount of work put in. The efficiency of each energy source varies with the level of technology.

ENERGY EFFICIENCY VS. TECHNOLOGY LEVEL

	Bioenergy	Solar/Wind	Hydro/Geo	Fossil Fuel	Nuclear
Stone Age	40%	20%	10%	0%	0%
Bronze Age	40%	20%	30%	10%	0%
Iron Age	60%	20%	30%	30%	0%
Industrial Age	60%	30%	50%	80%	10%
Atomic Age	70%	50%	50%	80%	80%
Information Age	80%	60%	60%	90%	90%
Nanotech Age	90%	80%	80%	90%	90%

The efficiency rating displayed and used in the REPORT WINDOW is averaged over the number of the various technologies. For example, if your planet has one city in the Nanotech Age, and one city in the Stone Age, then the displayed efficiency rating for Atomic Energy would be 45% (1 city * 90% + 1 city * 0% / 2 cities).

This rating can be changed by the availability of resources. As fossil fuel and atomic fuel run out, their efficiency rating declines to 0%.

ENERGY is the amount of each type of energy produced, with a total for all combined energy sources.

All energy that is produced is used. The total energy produced will roughly equal the total of all the allocated energy. There is some energy lost, and some rounding off of numbers for the display, but it all gets used.

ALLOCATION is what your sentients are doing with the energy. All the energy produced is allocated and used. Allocation is set on the right side of the CIVILIZATION MODEL CONTROL PANEL.

The possible uses that you can allocate energy to are:

PHILOSOPHY—Philosophy is a deterrent to war. Investing in philosophy reduces the number and intensity of violent conflicts on your planet.

SCIENCE—Investing in science helps your civilizations advance to higher technology levels. You must have at least some investment in science to advance at all. Advancing technology levels too fast, or without a fair share of philosophy, agriculture, medicine, and art/media does not produce a stable, long-lasting civilization. If you invest too much too soon in science, your population will die off from war and plague.

AGRICULTURE—Investing in agriculture increases food production, which increases the rate of population growth of your sentient species.

MEDICINE—Investment in medicine reduces the number and severity of plagues.

ART/MEDIA—Investment in art/media improves the quality of life of your SimEarthling global citizen.

CURRENT TASK tells you what needs to be accomplished to advance to the next Time Scale.

REPORT WINDOW IN THE DAISYWORLD SCENARIO

In the Daisyworld Scenario, you are only given four items of information.

MAJOR DAISY
This is a display of the shade of the most populous Daisy.

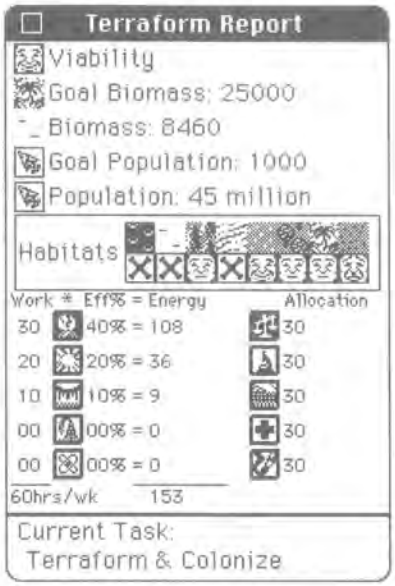
EMPTY SPACE
This shows you how much open land there is on the planet to fill with Daisies.

MAJOR ANIMAL
This shows the most populous animal (if any) on the planet.

CURRENT TASK
Your Daisy-raising goal.

REPORT WINDOW IN THE TERRAFORMING SCENARIOS

In the Terraforming Scenarios, Mars and Venus, you are given much of the same information as in the CIVILIZATION and TECHNOLOGY REPORT WINDOWS, but with added terraforming progress feedback.



VIABILITY

This rating tells you how hospitable your world is to life. Viability is based on the oxygen and dust content of the atmosphere. The rating levels are the same as in the GEOLOGICAL, CIVILIZATION, and TECHNOLOGY REPORT WINDOWS.

GOAL BIOMASS

This is the biomass that you must attain before the planet is considered terraformed.

BIOMASS

This is your world's present biomass. The icon shown for Biomass is the predominant biome.

GOAL POPULATION

This is the population your planet must reach to be considered colonized.

POPULATION

This is your present population.

HABITAT AND ENERGY

The HABITAT and ENERGY sections of this window are the same as in the CIVILIZATION and TECHNOLOGY REPORT WINDOWS, with two exceptions:

These sections will not appear in the window until you have begun the colonization process (placing sentient life on the planet).

The HABITAT section will always display the information for sentient mammals since the majority of SimEarth players are mammals.

CURRENT TASK

Your current task is to terraform and colonize the planet.

TUTORIAL WINDOW

The TUTORIAL WINDOW is a text window that gives a brief review of the tutorial in this manual. It can be accessed through the WINDOWS MENU.

Like all help and text windows in SimEarth, it can be moved around the screen and re-sized. Click on the up and down arrows in the Scroll Bar on the right side of the window to scroll through the text.

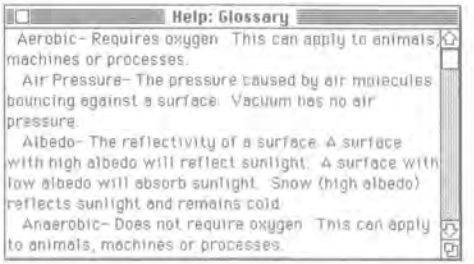
Depending on your computer, you may or may not be able to have this window open at the same time as the HELP WINDOW.

Help: SimEarth Tutorial
Welcome to SimEarth:The Living Planet. This window will give you a brief introduction to SimEarth and walk you through some of the basic functions.
Help screens such as this are available for almost every control, menu and button. To open the help window hold down the shift key and then click on the control, menu or button that you want information about.

GLOSSARY WINDOW

The GLOSSARY WINDOW is a special HELP WINDOW that can be accessed through the WINDOWS MENU. It gives definitions for words and terms that are used in the SimEarth program.

Like all help and text windows in SimEarth, it can be moved around the screen and re-sized. Click on the up and down arrows on the right side of the window to scroll through the text.


Help: Glossary
Aerobic- Requires oxygen. This can apply to animals, machines or processes.
Air Pressure- The pressure caused by air molecules bouncing against a surface. Vacuum has no air pressure.
Albedo- The reflectivity of a surface. A surface with high albedo will reflect sunlight. A surface with low albedo will absorb sunlight. Snow (high albedo) reflects sunlight and remains cold.
Anaerobic- Does not require oxygen. This can apply to animals, machines or processes.

GRAPHS

There are four graph windows, which can be opened through the GRAPHS MENU and through the MAP WINDOW icons. Only one GRAPH WINDOW can be displayed at a time.

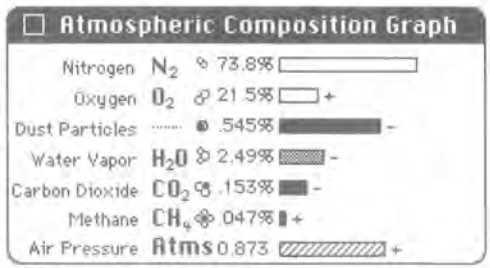
These windows can be moved around the screen by clicking and dragging the TITLE BAR, and closed by clicking the CLOSE BOX.

Two of the graphs display their information over time as well as for the present. The information is given in horizontal or vertical bars, with the most current bar in front.

ATMOSPHERIC COMPOSITION GRAPH

This graph is accessed either through the AIR SAMPLE item on the GRAPHS MENU or by double-clicking on the AIR TEMPERATURE icon on the MAP WINDOW CONTROL PANEL.

The ATMOSPHERIC COMPOSITION GRAPH gives only the atmospheric composition for the present time. Its information is shown in horizontal bars.


Atmospheric Composition Graph
Nitrogen N_2 73.8%
Oxygen O_2 21.5% +
Dust Particles .545% -
Water Vapor H_2O 2.49% -
Carbon Dioxide CO_2 .153% -
Methane CH_4 .047% +
Air Pressure Atms 0.873 +

It displays the chemical composition of your planet's atmosphere. It gives the ratio in percentages of four gases—Nitrogen (N_2), Oxygen (O_2), Carbon Dioxide (CO_2), and Methane (CH_4)—plus dust particles and water vapor (H_2O). It also gives the air pressure expressed in atmospheres.

The plusses and minuses at the end of the bars indicate whether that item is increasing or decreasing. If there is no plus or minus after the bar, the level is temporarily stable.

The shade or pattern of the bars is a scale indication.
■ Percentage is less than 1%.
▒ Percentage is between 1 and 10%.
□ Percentage is above 10%.
The Air Pressure bar has its own shade, and does not change with the percentage.

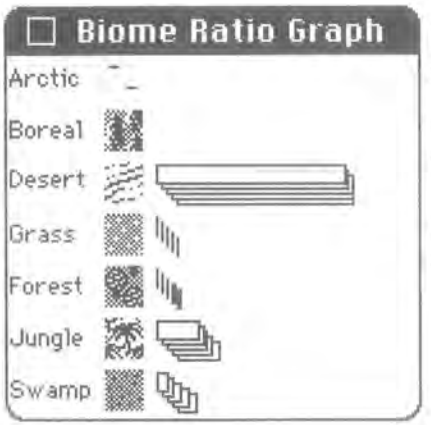
This graph is useful for monitoring trends in atmospheric composition:

Too little oxygen, and life will end.
Too much oxygen, and fires will burn all over the planet.
Too little carbon dioxide, and plants will die.

Too much carbon dioxide, and animals will become extinct.
Too much dust causes solar blockage and extinctions.
Water vapor affects rainfall.
Water vapor, carbon dioxide and methane are greenhouse gases—high levels will increase the greenhouse warming effect.

BIOME RATIO GRAPH

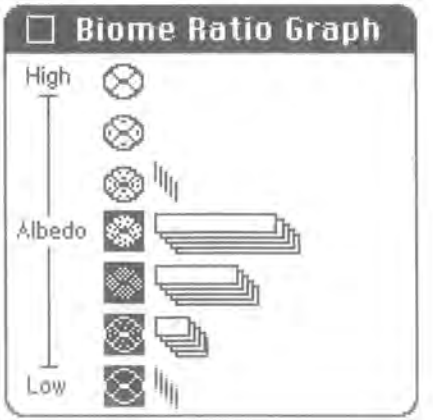
This graph is accessed either through the BIOMES item on the GRAPHS MENU or by double-clicking on the BIOMES icon on the MAP WINDOW CONTROL PANEL.



It displays the relative amounts of the seven biomes on your planet over time.

This graph is useful for detecting and tracking trends in the dominant biomes.

When playing the Daisyworld Scenario, the BIOME RATIO GRAPH displays the eight shades of daisies.

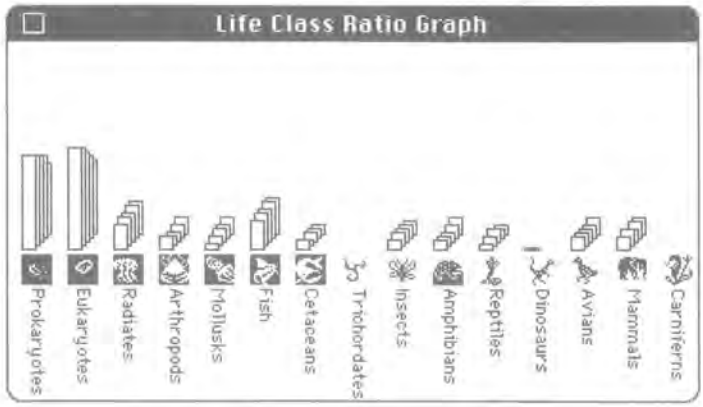


LIFE CLASS RATIO GRAPH

This graph is accessed either through the LIFE-FORMS item on the GRAPHS MENU or by double-clicking on the LIFE icon on the MAP WINDOW CONTROL PANEL.

It displays the relative amounts of the life classes on your planet over time. The 14 classes from the PLACE LIFE tool are displayed, plus the Carnifern: a mobile carnivorous plant that can achieve sentience.

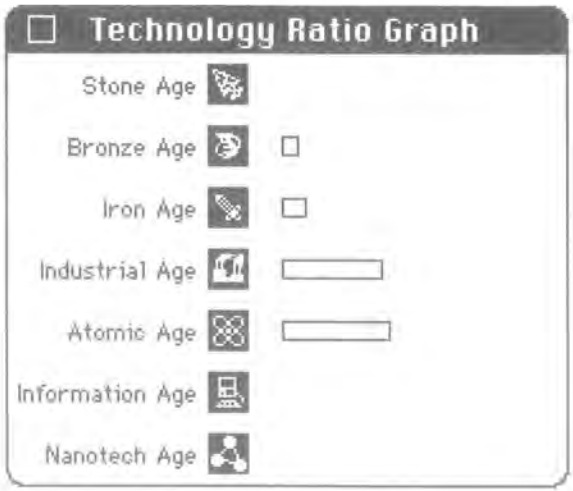
This graph is useful for tracking trends in the life on your planet.



TECHNOLOGY RATIO GRAPH

This graph is accessed either through the TECHNOLOGY item on the GRAPHS MENU or by double-clicking on the CIVILIZATION icon on the MAP WINDOW CONTROL PANEL.

It displays the population ratio between the various levels of civilization on your planet.



MODEL CONTROL PANELS

The four MODEL CONTROL PANELS are used to observe and change the settings of many variables in the model. These CONTROL PANELS are the only places in SimEarth that are used only for INPUT.

These windows are reached either through the MODELS MENU or through the MAP WINDOW CONTROL PANEL.

Only one MODEL CONTROL PANEL can be displayed at a time. You can cycle through the four panels forward or backward by clicking on the NEXT and LAST buttons in the upper-right corner.

There are 16 possible settings for each item on each control panel.

To change model settings, first click on the item you want to change. The name of the item and an indicator (usually an arrow) will become highlighted. A dotted box will appear around the indicator. Both the indicator and the SLIDER CONTROL at the right of the panel will display the setting of the active item.

Next, click on the SLIDER CONTROL above or below the slider to increase or decrease the setting one increment. You can also click and drag the slider to change settings.

Even though the life on your planet is self-regulating, and affects the model, these changes are not shown on the MODEL CONTROL PANELS. These panels reflect your settings and display only your changes.

There will be a lag between the time you change a MODEL CONTROL PANEL and the time your change takes effect.

The cost in energy for changing the control panels is 30 E.U. per click and 150 E.U. per drag. For small changes, use clicks. For big changes use drags.

If you change a panel from the lowest to the highest setting by clicking, it will cost you 30 E.U. X 15 clicks = 450 E.U. The same change by dragging would cost 150 E.U. You would save a lot of energy by dragging instead of clicking.

If you change a panel setting one level, clicking would cost you 30 E.U., but dragging would still cost 150 E.U.

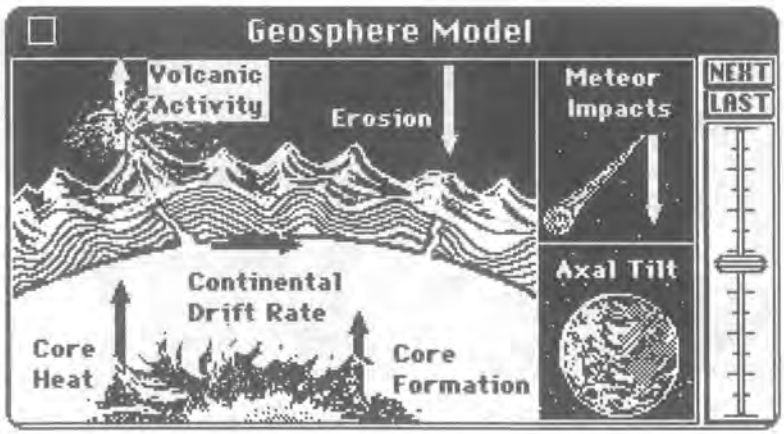
GEOSPHERE MODEL CONTROL PANEL

This MODEL CONTROL PANEL deals with the variable factors affecting the Geosphere, Meteor Impacts, and the Axial Tilt of your planet.

It can be accessed through the MODELS MENU or by clicking on the GEOSPHERE icon in the MAP WINDOW CONTROL PANEL.

Geosphere

The factors you can adjust are:



VOLCANIC ACTIVITY controls the frequency of periodic volcanic eruptions. In early stages of the planet this will influence the formation of continental areas.

EROSION controls the rate of "smoothing" of the terrain by erosion. Increasing erosion also increases CO_2 in the atmosphere.

CONTINENTAL DRIFT controls the rate at which the continents move on the magma layer.

CORE HEAT controls the temperature of the planet's core. The higher the core heat, the larger and more severe the volcanos. Also, the hotter the core, the more the direction of magma flow will change.

CORE FORMATION controls the rate at which the planetary core forms. As the core forms, it gets larger. The size of the core affects the speed at which the magma flows. The bigger the core, the slower the magma. The slower the magma, the smaller the volcanos, and the slower the continental drift.

METEOR IMPACT controls the frequency of periodic meteor (or planetesimal) strikes.

AXIAL TILT controls the tilt of your planet's spin axis. This affects the severity of the seasons—the greater the tilt, the greater the seasonal severity. This is only noticeable in the two modern Time Scales. The current tilt of the real Earth's axis is about 22 degrees from vertical.

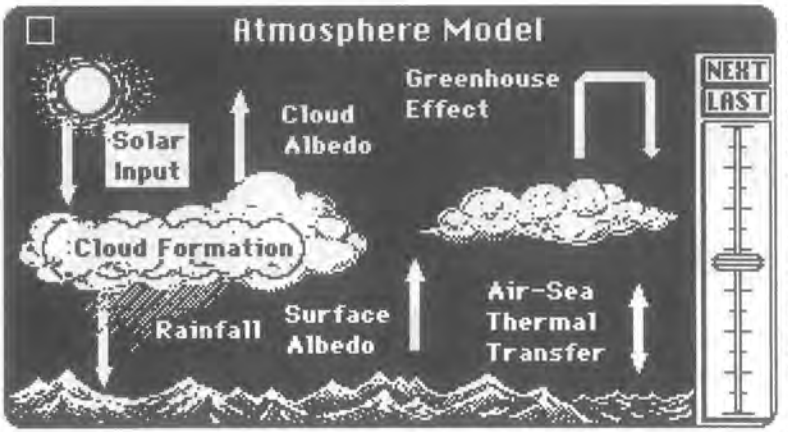
ATMOSPHERE MODEL CONTROL PANEL

Atmosphere

This MODEL CONTROL PANEL deals with the variable factors affecting the atmosphere of your planet.

It can be accessed through the MODELS MENU or by clicking on the ATMOSPHERE icon in the MAP WINDOW CONTROL PANEL.

The factors you can adjust are:



SOLAR INPUT controls the incoming solar radiation (heat). This is the amount of heat from the Sun that hits your planet. Setting the slider all the way down will turn the sun off.

CLOUD ALBEDO controls the reflectivity of the clouds, which controls the amount of sunlight (heat) that passes through them to the planet.

GREENHOUSE EFFECT controls the intensity of the warming greenhouse effect. The greenhouse effect is caused by certain gases that block outgoing infrared radiation. In SimEarth, the greenhouse gases are water vapor (H_2O), methane (CH_4), and carbon dioxide (CO_2).

CLOUD FORMATION controls the amount of clouds formed from a given amount of evaporation.

RAINFALL controls the amount of rainfall on the planet.

SURFACE ALBEDO controls the reflectivity of surface biomes. The higher the albedo, the more solar radiation is reflected back into space.

AIR-SEA THERMAL TRANSFER controls the rate at which the air and ocean can exchange heat.

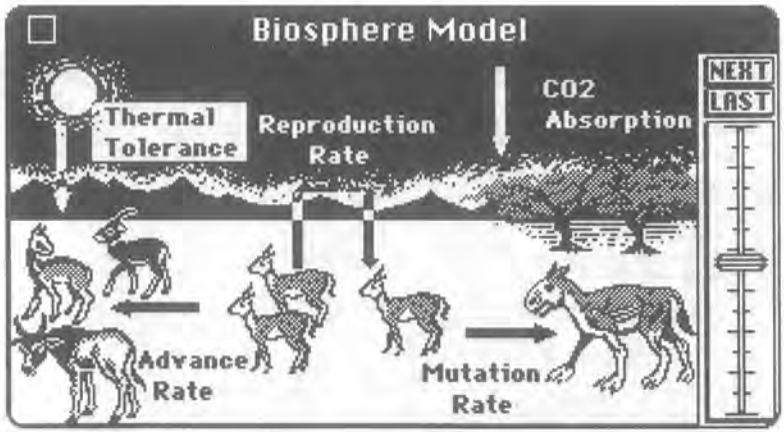
BIOSPHERE MODEL CONTROL PANEL

Bio

This MODEL CONTROL PANEL deals with the variable factors affecting the biosphere of your planet.

It can be accessed through the MODELS MENU or by clicking on the BIOSPHERE icon in the MAP WINDOW CONTROL PANEL.

The factors you can adjust are:



THERMAL TOLERANCE controls the temperature range in which life can survive. The higher the setting, the wider the acceptable temperature range for life.

REPRODUCTION RATE controls how quickly life as a whole will reproduce.

CO_2 ABSORPTION controls how much carbon dioxide is scrubbed from the air by the plants.

ADVANCE RATE controls the rate at which life-forms advance to the next higher level of development towards intelligence. It is usually a change of one species.

MUTATION RATE controls the rate at which life-forms will mutate. Mutations can jump ahead, skipping species, to the next class of life.

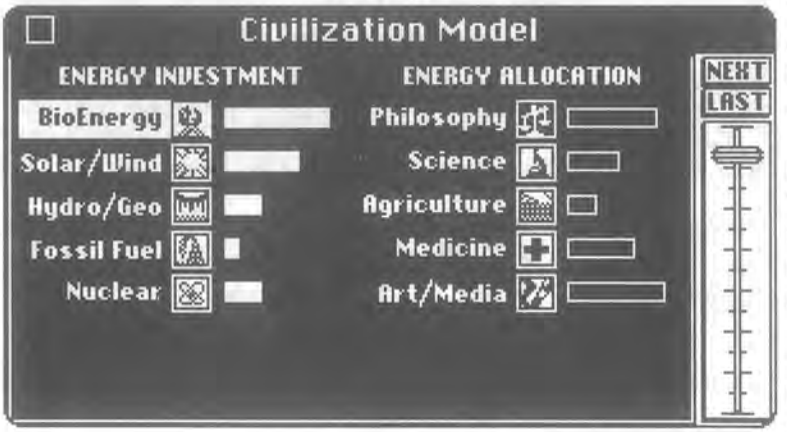
CIVILIZATION MODEL CONTROL PANEL

Civ

This panel is used to define and control the civilized, sentient species on your planet. It is only useful in the Civilization and Technology Time Scales.

It can be accessed through the MODELS MENU or by clicking on the CIVILIZATION icon in the MAP WINDOW CONTROL PANEL.

The CIVILIZATION MODEL CONTROL PANEL is one of the real challenges of SimEarth. You must make some important decisions and set priorities both for the types of energies you want to invest in and the uses you want to put the energy to.



This control panel has a major effect on the REPORT WINDOW. It is a good idea to have these two on the screen together.

ENERGY INVESTMENT

The left side of the control panel is where you set your priorities for investment in various types of energies.

The greater your priority, the longer you should make the bar next to the choice. If you don't want to invest in a particular type of energy at all, then shrink the bar to nothing.

The total amount of investment in all the types of energy sets the amount of hours your global citizen must work per week. The work week is a major factor affecting quality of life.

The types of energy you can invest in are:

BIOENERGY—Burning wood, animal power, plant power (farming), work done by hand by the sentient species.

SOLAR/WIND—Sun-drying of food and clothes, windmills, sailing ships, solar heating, wind-powered generators, solar electric cells, satellites collecting solar energy.

HYDRO/GEO—Waterwheels, dams, steam power, hydroelectric power, geothermal power.

FOSSIL FUEL—Coal made from long-dead animals.

NUCLEAR—Atomic reactors, bombs, etc.

ENERGY ALLOCATION

The right side of the control panel is where you allocate the energy. All energy produced is used.

Rather than actual numerical settings, allocations are ratios. This means that you should adjust the length of the bars for each allocation choice to show your priorities—the longer the bar, the higher the priority.

If all the bars are all the way up, or all are in the middle, the model interprets your settings the same. It is the differences in lengths that matters, not the actual length.

It is best not to turn any of the settings all the way off. The allocation setting has a feedback effect on the energy investment. Low allocations can reduce the efficiency at which technologies can produce the energy. This can make your technology level decline.

The uses to which you can put your energy are:

PHILOSOPHY—Philosophy is a deterrent to war. Investing in philosophy reduces the number and intensity of violent conflicts on your planet.

SCIENCE—Investing in science helps your civilizations advance to higher technology levels. You must have at least some investment in science to advance at all. Advancing technology levels too fast, or without a fair share of philosophy, agriculture, medicine, and art/media does not produce a stable, long-lasting civilization. If you invest too much too soon in science, your population will die off from war and plague.

AGRICULTURE—Investing in agriculture increases food production, which increases the rate of population growth of your sentient species.

MEDICINE—Investment in medicine reduces the number and severity of plagues.

ART/MEDIA—Investment in art/media improves the quality of life of your SimEarthling global citizen.

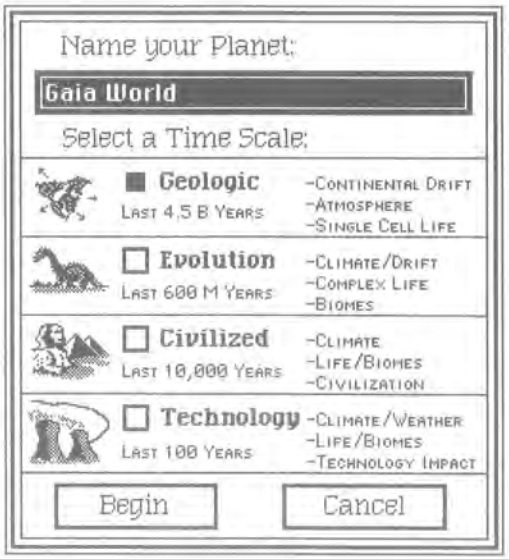
TIME SCALES

INTRODUCTION TO TIME SCALES

SimEarth runs in four different Time Scales: Geologic, Evolution, Civilization and Technology. Each Time Scale simulates a different set of factors on the planet. You can start a planet at any Time Scale, or start at the first (Geologic) and the game will automatically evolve through all the Time Scales.

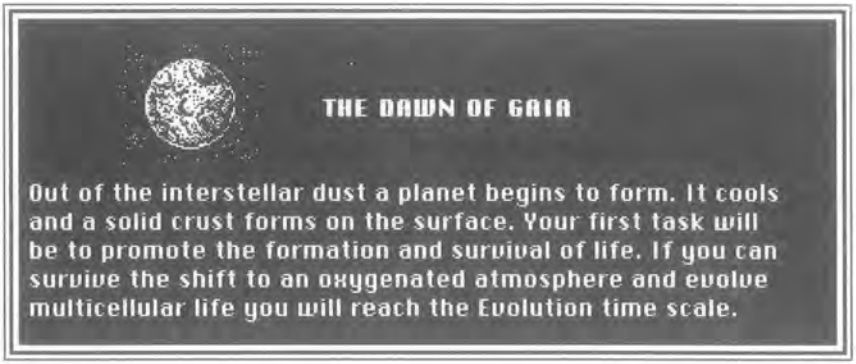
In the Civilization and Technology Time Scales, you can rush the intelligent SimEarthling's advance through the levels of civilizations by model manipulation or by using the Monolith.

Advancing too fast is not necessarily a good thing. If you do not allow enough time in the Geologic and Evolution Time Scales, there won't be enough fossil fuel for the later Time Scales. You will need a wide population base for continued advancement. If you push a small group to advance before its population has built up, it will stagnate and die out.



GEOLOGIC TIME SCALE

The Geologic Time Scale begins just after a planet is formed and begins cooling. It ends with the development of multi-celled life. This covers the time period on the real Earth from 4.5 billion to 570 million years ago.


THE DAWN OF GAIA
Out of the interstellar dust a planet begins to form. It cools and a solid crust forms on the surface. Your first task will be to promote the formation and survival of life. If you can survive the shift to an oxygenated atmosphere and evolve multicellular life you will reach the Evolution time scale.

In this Time Scale, the planet changes very slowly, so the simulation time is sped up to keep things moving. The Time/Simulation cycle for this Time Scale is 10 million years. This means that each time the program runs through one simulation cycle, 10 million years passes on the planet.

Your available energy builds up at 1 E.U. per Time/Simulation cycle.

The factors simulated in this Time Scale, in order of their influence, are: continental drift, atmospheric composition, extraterrestrial collisions, single-celled life, and climate.

The goal of this Time Scale is to manipulate all the simulated factors to facilitate the formation of multicellular life, at which time you will be advanced to the next and slower Time Scale, Evolution.

Time moves very fast in this Time Scale, and your planet only has 10 billion years to live. If you want to complete all the Time Scales before the end of your planet, you should try to reach the next Time Scale when your planet is between three and four billion years old. Don't advance too soon, or there will not be enough fossil fuels for later civilizations.

SUMMARY—GEOLOGIC TIME SCALE

Time/Simulation cycle	10 million years
Energy increase/cycle	1 E.U.
Time on real Earth	4.5 to .570 billion years ago
Factors simulated	Continental drift Atmospheric composition Extraterrestrial collisions Single-celled life Climate
Advancement conditions	Evolution of multicellular organisms
Optimum advancement age	Between 3 and 4 billion years

THINGS TO DO:

Design continents.

Spell your name in land masses.

Burn off oceans.

Make life impossible in a number of ways.

Use earthquakes to create mountain ranges.

Use meteors to create lakes.

Use meteors and hurricanes to increase rainfall.

Use earthquakes, volcanos and meteors to achieve the highest dust level you can.

Using only events (not the ALTITUDE tool), try to recreate the continents on Earth today. (Hint: you'll want to pause the simulation or at least turn the core heat all the way down to stop or slow continental drift.)

Play Bumper-continents. Get two or three friends, each build a small continent, and take turns setting off earthquakes to propel the continents into each other.

EVOLUTION TIME SCALE

The Evolution Time Scale comes after the Geologic Time Scale. It begins with the appearance of multicellular organisms and ends with the development of intelligence.

EVOLUTION TIME SCALE
The Invasion of Land - The Cambrian Era on earth saw a vast diversification of lifeforms, the beginning of the plant and animal kingdoms, and the first steps of life on land. Now you must survive periodic extinctions and promote intelligence to reach the Civilization time scale.

Things change a little faster in this Time Scale than in the Geologic, so the Time/Simulation cycle has been lowered to 500,000 years.

Your available energy builds up at 1 E.U. per Time/Simulation cycle.

This Time Scale relates to the period of time on the real Earth from 570 to .01 million years ago.

The factors simulated in this Time Scale, in order of their influence, are: life, biomes, climate, atmospheric composition and continental drift.

The goal of this Time Scale is to manipulate the simulation factors and evolve intelligence, at which time you will be advanced to the Civilization Time Scale.

Your planet only has 10 billion years to live. If you want to complete all the Time Scales before the end of your planet, you should try to reach the next Time Scale when your planet is between five and six billion years old. Don't advance too soon, or there will not be enough fossil fuels for later civilizations.

SUMMARY—EVOLUTION TIME SCALE

Time/Simulation cycle	500,000 years
Energy increase/cycle	1 E.U.
Time on real Earth	570 to .01 billion years ago
Factors simulated	Life
	Biomes
	Climate
	Atmospheric composition
	Continental drift
Advancement conditions	Development of intelligence
Optimum advancement age	Between 5 and 6 billion years

THINGS TO DO:

Choose and help a particular class of life to develop intelligence.

Prevent particular species from developing intelligence.

Manipulate the evolutionary path.

Try to get Carniferns to reach intelligence without using the Monolith.

Try to get the highest biomass rating you can.

Try to maintain a valley or island of dinosaurs in the midst of a civilized world.

Play with the atmosphere and see what happens.

Raise the terrain all over the planet, and see what happens.

See how much and how little of your planet you can have as land without major repercussions to life.

CIVILIZATION TIME SCALE

The Civilization Time Scale comes after the Evolution time scale. It begins with the appearance of intelligent organisms and ends with the Industrial Revolution.

CIVILIZATION TIME SCALE
The evolution of intelligent life has brought you to the Civilization time scale. GAIA begins to achieve consciousness. Now you must spread your civilization across the planet and advance technology. The dawn of the industrial revolution will bring you into the Technology time scale.

Things change fast in this Time Scale, so the Time/Simulation cycle has been lowered to 10 years.

Your available energy builds up at different rates, depending on your highest available technology level:
2 E.U. per Time/Simulation cycle in the Stone Age,
3 E.U. per Time/Simulation cycle in the Bronze Age, and
4 E.U. per Time/Simulation cycle in the Iron Age.

This Time Scale relates to the period of time on the real Earth from 10,000 to 100 years ago.

The factors simulated in this Time Scale, in order of their influence, are: civilization, life, biomes, climate, and atmospheric composition.

The goal of this Time Scale is to manipulate the simulation factors and evolve higher levels of technology, at which time you will be advanced to the Technology Time Scale.

Your planet only has 10 billion years to live. If you want to complete all the Time Scales before the end of your planet, you should try to reach the next Time Scale before your planet is 9.5 billion years old.

SUMMARY—CIVILIZATION TIME SCALE

Time/Simulation cycle	10 years
Energy increase/cycle	2 E.U.—Stone Age
Energy increase/cycle	3 E.U.—Bronze Age
Energy increase/cycle	4 E.U.—Iron Age
Time on real Earth	10,000 to 100 years ago
Factors simulated	Civilization
	Life
	Biomes
	Climate
	Atmospheric composition
Advancement conditions	Development of higher technology
Optimum advancement age	Less than 9.5 billion years

THINGS TO DO:

Cause or prevent wars.

Eliminate unwanted technologies.

Promote or eliminate various energy sources.

Mold the sentient species to your liking through the CIVILIZATION MODEL CONTROL PANEL.

Improve the quality of life for your sentient species.

Set up equivalent civilizations on different continents, and let them race to the Technology age.

Vary the altitude, biomes, etc. for the two civilizations, and see what helps and hinders.

Try to control pollution.

TECHNOLOGY TIME SCALE

The Technology Time Scale comes after the Civilization Time Scale. It begins with the appearance of high levels of technology, and ends when technology evolves to the level when your planet can reproduce itself through interstellar "genetic" seeding—the ability to colonize other planets.

TECHNOLOGY TIME SCALE
The industrial revolution has occurred! Civilization grows rapidly now as breakthroughs are made in energy production, medicine and agriculture. But beware, civilization is also beginning to have a significant impact on the planet.

When you complete this Time Scale, and achieve interstellar migration, all civilization leaves the planet. The planet is then turned into a wildlife reserve, and returns to the Evolution Time Scale.

Things change very fast in this Time Scale, so the Time/Simulation cycle has been lowered to one year.

Your available energy builds up at different rates, depending on your highest available technology level:
5 E.U. per Time/Simulation cycle in the Industrial Age,
6 E.U. per Time/Simulation cycle in the Atomic Age,
7 E.U. per Time/Simulation cycle in the Information Age, and
8 E.U. per Time/Simulation cycle in the Nanotech Age.

This Time Scale relates to the period of time on the real Earth from 100 years ago to the future.

The factors simulated in this Time Scale, in order of their influence, are: civilization, life, biomes, sentient expansion, climate, and atmospheric composition.

The goal of this Time Scale is to manipulate the simulation factors and evolve a level of technology high enough to colonize other planets.

Your planet only has 10 billion years to live. You should try to complete this Time Scale before the end of your planet.

SUMMARY—TECHNOLOGY TIME SCALE

Time/Simulation cycle	1 year
Energy increase/cycle	5 E.U.—Industrial Age
Energy increase/cycle	6 E.U.—Atomic Age
Energy increase/cycle	7 E.U.—Information Age
Energy increase/cycle	8 E.U.—Nanotech Age
Time on real Earth	100 years ago to the future
Factors simulated	Civilization
	Life
	Biomes
	Climate
	Atmospheric composition
Advancement conditions	Development of high enough technology to colonize other planets.
Optimum advancement age	Less than 10 billion years old (before the planet dies)

THINGS TO DO:

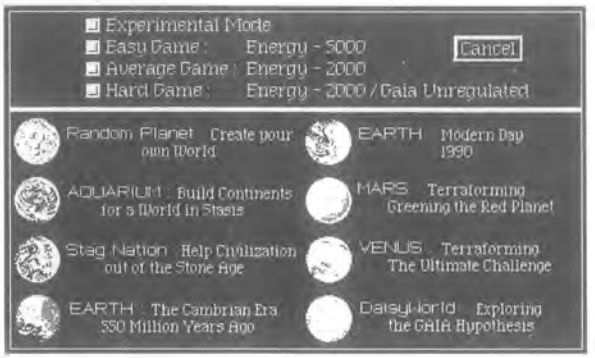
Prevent the sentient creatures from destroying themselves.
Cause or prevent wars.
Eliminate unwanted technologies.
Return the planet to ignorant bliss.
Move cities of different technologies close to each other, and see what happens.
Control pollution.
Test the greenhouse effect.

SCENARIOS

There are six scenario planets included with SimEarth, plus the Daisyworld Scenario. They can all be played in easy, medium, hard, and experimental modes.

Each scenario has a task for you to accomplish, but feel free to just play with these worlds.

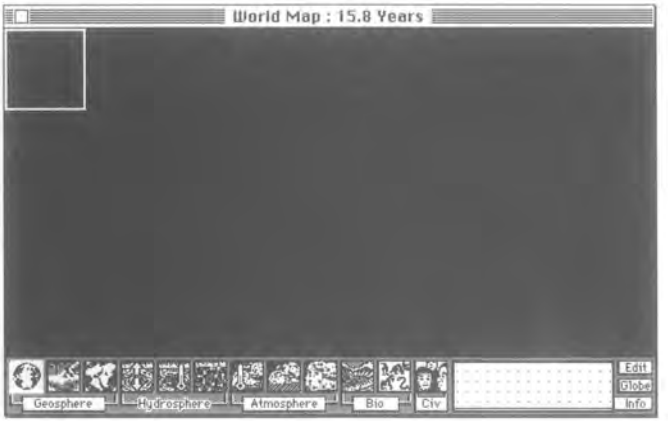
Scenarios are chosen and started in the NEW PLANET WINDOW.


Experimental Mode
Easy Game : Energy - 5000
Average Game : Energy - 2000
Hard Game : Energy - 2000 / Gaia Unregulated
Cancel
Random Planet : Create your own World
EARTH : Modern Day 1990
AQUARIUM : Build Continents for a World in Stasis
MARS : Terraforming Greening the Red Planet
Stag Nation : Help Civilization out of the Stone Age
VENUS : Terraforming The Ultimate Challenge
EARTH : The Cambrian Era 550 Million Years Ago
Daisyworld : Exploring the GAIA Hypothesis

AQUARIUM

Aquarium is a world that will never develop sentient life. Sentience can only be reached in SimEarth by land animals. We hope we're not offending any intelligent, purely aquatic aliens anywhere in the universe, but as far as we can tell, civilization requires the use of fire and the burning of fossil fuels to develop.

Intelligence in SimEarth requires land because of the need of fire, tools, and forges. Water creatures can reach intelligence, but need access to land for tool-making.



The problem: No continents

Time Scale: Evolution

Your mission: Create continents on this planet so civilization can evolve.

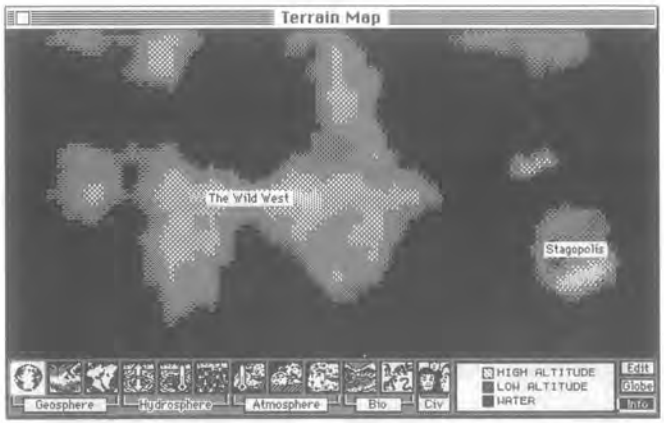
The methods: The easy way is to use the SET ALTITUDE tool. A more creative approach is to use events. The most subtle method is by manipulating the MODEL CONTROL PANELS.

Hints: Make sure you keep plenty of shelves (shallow water) in your oceans. Most marine life lives near the surface.

Notes: Aquarium is a good starting place for people who like to design their own continents.

STAG NATION

The civilization on this world is trapped in the Stone Age. The sentient mammals are all stuck on a small island. They have no room to expand, and are unable to develop or expend energy for a technological jump.



The problem: Population stuck in the Stone Age.

Time Scale: Civilization

Your mission: Aid the population in a migration to larger land masses, and increase their level of science.

The methods: The advancement in science will require manipulation of the CIVILIZATION MODEL CONTROL PANEL. The migration can be performed in a number of ways: pick them up and move them to a larger landmass with the MOVING tool; build a land bridge for them to cross with the SET ALTITUDE tool; or use events.

Hints : If you use events to make a land bridge, be careful not to wipe out your sentient population by accident.

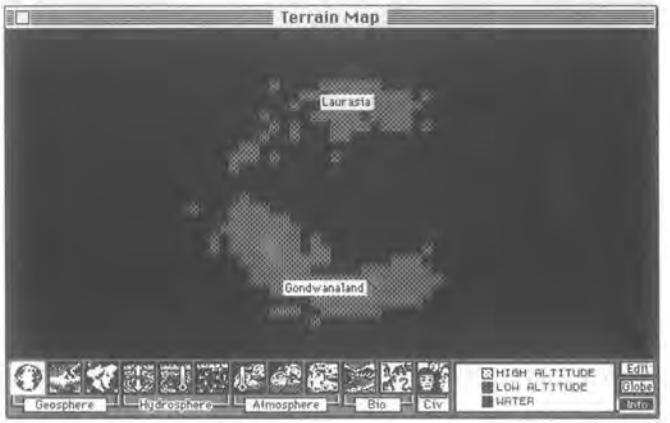
Notes: If you don't like intelligent Mammals, you can destroy the island where they live, and try to nurture another class of life to sentience.

EARTH: THE CAMBRIAN ERA

This scenario takes place on Earth 550 million years ago at the beginning of the Cambrian era. Life on Earth at that time was undergoing an explosion of diversification. Plants started moving onto the land, followed by insects and other animals.

In this scenario, the drift of the continents will follow the drift of Earth's continents. It starts with the supercontinent called Pangaea, which then splits apart into the ancient continents of Gondwanaland and Laurasia.

Eventually, you will recognize the continents as we see them today. The pre-programmed drift will continue into the future following scientific predictions for about 200 million years. After that, the simulation takes over and controls the drift.



The problem: Living in the past

Time Scale: Evolution

Your mission: Help evolution develop intelligent life while seeing an instant replay of our planet's continental drift.

The methods: On this one, you can just sit back and watch, or get involved in every planetary process. The continents will drift whether or not any life is around to see where they go.

Hints: Beyond 200 million years in the future, the drift will diverge from scientific predictions, and will be at the whim of our simulation code.

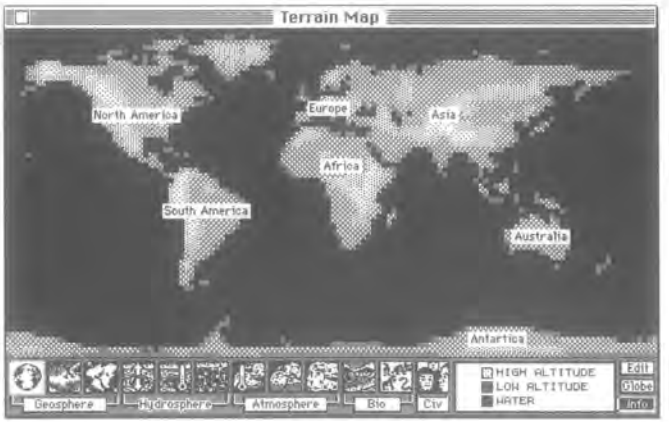
To see a real instant replay of the continental drift, click and hold on the INFO BOX and slowly drag the mouse back and forth.

Any changes you make to the continents by using events will disappear. The continental drift will follow its pre-programmed path no matter what you do.

Notes: Try to develop intelligence/civilization in your sentient species just as the continents reach the stage of modern Earth. See if you can create an earth with intelligent dinosaurs.

EARTH: MODERN DAY

This scenario takes place on the Earth of today. We live in a world with pollution, war, famine, greenhouse warming, energy shortages, and the possibility of nuclear winter.



The problems: Too many to list here. Read your newspaper.

Time Scale: Technology

Your mission: Solve all the world's problems and lead us into a future of peace, abundant food, clean air, and plentiful energy.

The methods: If I knew how to solve all these problems, I'd be running the U.N. instead of making computer games.

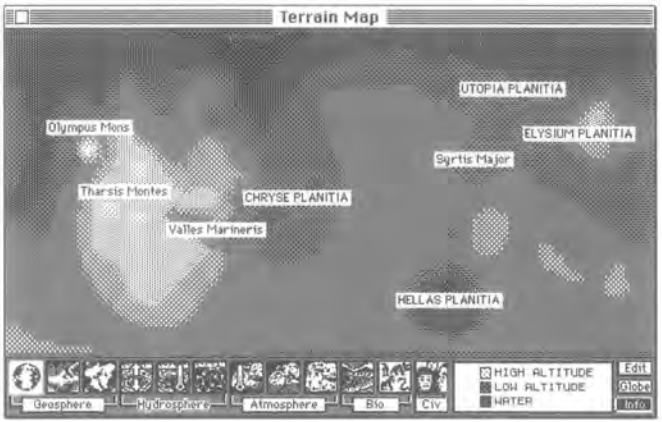
Hints: The best way to prevent war in SimEarth is to allocate energy to philosophy in the CIVILIZATION MODEL CONTROL PANEL. Increasing allocation to Agriculture will increase the food supply. Allocating to Art/Media improves the quality of life. Wars and plague have a greater impact in this scenario than they do in the real world.

Notes: This scenario can be difficult, but still more fun than the real thing. If you click and hold on the Terrain Map Icon in the MAP WINDOW, you will see the names of the continents displayed. If you click and hold on the Drift icon in the MAP WINDOW you will see the names of the major tectonic plates displayed.

MARS

For this scenario, you are a citizen in a nanotech level society. Your home planet is overcrowded, and the population is increasing.

You show up for work, and find a memo from the boss that informs you that you've been put in charge of a new project. The promotion involves a small raise, but you'll have to move—to Mars. Your new job is to turn Mars into a planet capable of supporting human life. If you fail to complete this project within 500 years you'll be fired.



The problem: No water, almost no atmospheric pressure, no oxygen, no plants, no animals, no nothing—except rock. The average temperature is -53 degrees C.

Time Scale: Technology

Your mission: Terraform Mars and make it a place fit for human occupation, and colonize the planet.

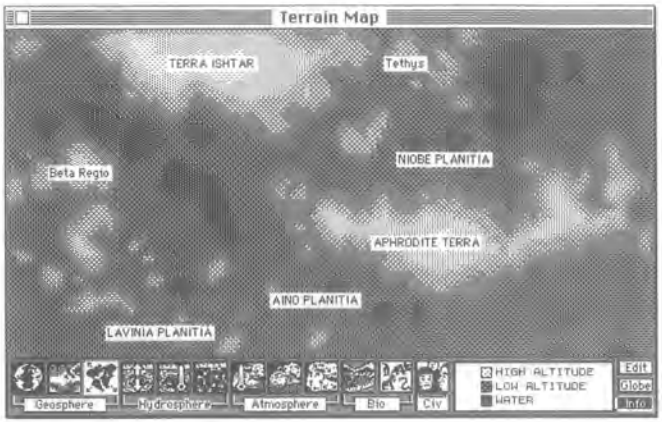
The methods: The MODEL CONTROL PANELS (except for the CIVILIZATION MODEL CONTROL PANEL) have been disabled to make this a challenge. You'll need the TERRAFORMERS available through the PLACE LIFE tool. Gaian regulation has been disabled—no life will spontaneously generate. The REPORT WINDOW gives you special feedback on your terraforming progress.

Hints: Start off with a few ice meteors to create oceans. Then start producing CO_2 and other greenhouse gases to build up atmospheric pressure and begin planetary warming. Use the CO_2 generator or better yet, plant some single-celled life in the oceans—they are more efficient than terraformers at building an atmosphere.

Notes: Click and hold on the TERRAIN MAP icon in the MAP WINDOW to see a display of Martian landmarks. Landmark names shown in all capital letters designate large regions, other names designate smaller regions or individual spots.

VENUS

Venus is SimEarth's ultimate challenge in terraforming. While Mars is far too cold, Venus is far too hot for life: its average temperature is 477 degrees C.



The problem: Too hot for life

Time Scale: Technology

Your mission: Cool this planet down, and make it a fit place for Earth life-forms.

The methods: The MODEL CONTROL PANELS (except for the CIVILIZATION MODEL CONTROL PANEL) have been disabled. You'll need the TERRAFORMERS available through the PLACE LIFE tool. Gaian regulation has been disabled—no life will spontaneously generate. The REPORT WINDOW gives you special feedback on your terraforming progress.

Hints: The first thing you have to do is cool the planet down. Ice meteors won't help—but go ahead and try them if you want. It's so hot that ice meteors melt and boil off into water vapor. Since water vapor is a greenhouse gas, it just makes things hotter.

To cool things down, you've got to reduce the greenhouse effect. The Oxygenator takes CO_2 (a greenhouse gas) out of the atmosphere. As soon as it cools enough, start placing biomes on Venus, which will also lower the CO_2 in the air. When placing biomes, remember that the higher the elevation, the cooler the temperature.

Notes: Click and hold on the TERRAIN MAP icon in the MAP WINDOW to see a display of Venusian landmarks. Landmark names shown in all capital letters designate large regions, other names designate smaller regions.

DAISYWORLD

Unlike the other scenario planets, the terrain of Daisyworld is randomly generated each time you load it.

According to the Gaia theory, life and the environment together constitute a system that self-regulates climate and atmospheric composition.

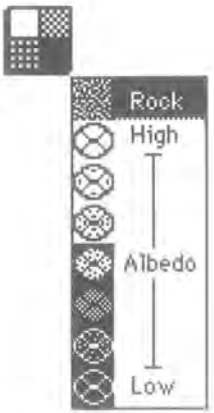
This scenario is based on the original Daisyworld program James Lovelock developed as a test of the Gaia theory.

During the past 3.6 billion years, the output of heat from the Sun has increased by 25%, but the Earth's average temperature has remained almost unchanged during the same time period.

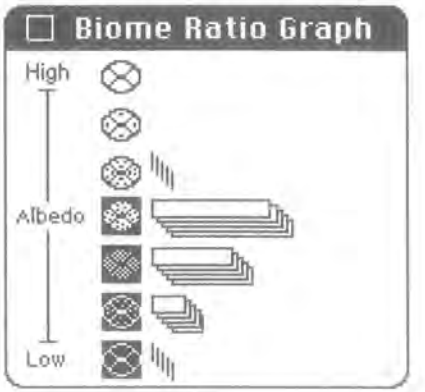
According to theory, Gaia has controlled the temperature to keep Earth cool enough for life. Daisyworld tests Gaia's ability to regulate temperature.

In Daisyworld, as in all SimEarth planets and scenarios (and real life), the Sun's heat output is slowly but constantly increasing. If Gaian regulation works, the average temperature on the planet should remain fairly constant in spite of the increasing solar radiation.

The biomes have been changed to eight shades of Daisies. The different shades, ranging from white to black, reflect different amounts of light and heat that regulate the planet's temperature.



Daisies are available for planting in the PLANT BIOME tool. The ratio of the various shades of Daisies can be tracked in the BIOME RATIO GRAPH.



The problem: The heat from the Sun is steadily increasing. If it isn't somehow regulated, the oceans will boil off and all life on this planet will die.

Time Scale: N/A

Your mission: Test Gaia's ability to regulate temperature, and fill the world with Daisies.

The methods: Keep an eye on the Temperature Map and the Air Temperature graph in the HISTORY WINDOW to observe the regulation cycles.

The REPORT WINDOW gives you special feedback on your Daisy-raising progress.

Hints and cautions: Place life on the planet to eat the Daisies. See how this complication affects regulation.

Notes: There will eventually be a breakdown point where the heat from the Sun is too great for Gaia to regulate. Adding or subtracting land areas where Daisies can live will move this breakdown point forward or backwards.

Also note the change in the Daisies' color as the landmass increases and decreases.

Try testing the stability of the system by killing off many of the Daisies. How many can be killed before the system collapses? How much of the planet's surface must be covered by Daisies for regulation to occur?

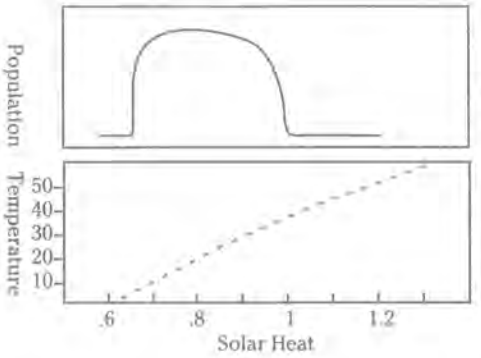
HOW DAISYWORLD WORKS

Daisyworld is a planet like Earth, but with few clouds and a constant low concentration of greenhouse gases. The output from the planet's sun is constantly increasing.

The planet's temperature is a balance between the heat received from the sun and the heat loss by radiation from the planet to space. The albedo—the reflectiveness—of the planet determines the temperature.

The planet is well-seeded with Daisies, whose growth rate is a function of temperature. There are two colors of Daisies: Black and White, which only grow between 5 and 40 degrees C, and grow best at 22.5 degrees C. Assume plenty of water and nutrients for the plants.

Taking into account only the heat from the sun and the albedo of the planet, we get the results in the following graphs.



The bottom graph shows the increasing solar heat (dotted line). The temperature of the planet rises in direct proportion to the increase of solar heat. The top graph shows life on the planet (Daisies) during the same time.

When the temperature hits 5 degrees C the Daisies begin to grow. When the temperature hits 40 degrees C they all die.

Now we add the albedo (heat and light reflectiveness) of the Daisies to the system.

When the planet's temperature reaches 5 degrees C, Daisies begin to grow. During the first season, the Black Daisies will grow better since they will be warmer than the planet's surface (dark colors absorb heat). White Daisies won't grow very well, since they reflect heat and will be colder than the planet's surface.

At the end of the first season there will be many more Black Daisy seeds in the soil that will soon grow. As the Black Daisies spread, they will not only warm themselves, but the whole planet.

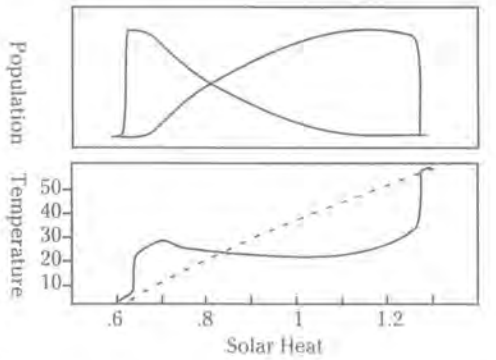
Eventually, because of the warming from both the Black Daisies and the Sun, the planet's temperature will rise to 22.5 degrees C. Since the Black Daisies are warmer than the planet, they are above their optimum living temperature, and their growth rate will slow.

Since the White Daisies are cooler than the planet, they will start to grow better as the temperature gets higher. When there are enough White Daisies, they will reflect enough heat to cool the planet.

The results are shown in the graphs on the next page.

The bottom graph still shows the same rise in solar heat (dotted line). It also shows the planetary temperatures (solid line) which have been affected by the presence of the Daisies.

The top graph shows the population of the two types of Daisies—when it's colder the Black Daisies grow better and as it warms up, the White ones grow better.



Eventually, the solar heat gets so great that the White Daisies cannot reflect enough heat to cool the planet.

The important thing to note here is that the life on the planet affected the climate of the planet in a way that is beneficial to life. It regulated the temperature, and nearly doubled the amount of time life could survive.

This is only a simple demonstration, and only deals with one life-form and one climactic feature, but it does demonstrates the two-way connection between life and environment.

INSIDE THE SIMULATION

EVENTS

Events are noteworthy occurrences on your planet. They will happen randomly, controlled by the simulation, and you can cause most of them to happen through the TRIGGER EVENTS TOOL in the EDIT WINDOW.

The cost in energy for triggering an event is 50 E.U.

There are 11 events in SimEarth, eight of which can be triggered manually:

HURRICANE—A Hurricane is a tropical cyclone with winds of 74 m.p.h. or greater, usually accompanied by rain, thunder and lightning. Hurricanes can cause tidal waves.

They can wipe out cities and destroy a lot of life. In SimEarth, hurricanes are caused by warm oceans. The only way to defend against them is to keep your oceans cool.

You can use hurricanes to increase rainfall in specific areas on your planet.

TIDAL WAVE—An unusually high sea wave that can be caused by earthquakes, high winds, hurricanes, volcanos and meteor impact.

Tidal waves can destroy coastal cities and land life. They generally travel from deeper water to shallower water.

Tidal waves are useful for eliminating unwanted coastal cities.

METEOR—Meteors are huge hunks of rock from space that smash into the planet, causing much damage and creating craters on land and tidal waves in the sea.

Meteors that crash into the land will put dust into the air. Too much dust will block the sun and cause extinctions. Meteors that crash into water put water vapor into the air, increasing rainfall. Meteorites also affect magma flow.

Meteors are useful for adding water vapor to the atmosphere (increasing rainfall), creating lakes in large land masses, and destroying pesky life-forms.

VOLCANO—A volcano is a vent in the planetary crust that lets a flow of molten rock to the surface. Volcanos raise the terrain elevation, creating mountains on land and islands in the sea. Volcanos in the ocean cause tidal waves. The severity of volcanos is less when the planet is young and the core is large.

Volcanos in SimEarth are huge upwellings that make recent real Earth events like Krakatoa look like pimples.

Volcanos put a lot of dust into the air, which can block the sun and cause extinctions. They also add a lot of carbon dioxide to the air, which is great for plants, but above a certain point, bad for animals.

Volcanos are useful for creating islands and mountains, and for doing general damage to life-forms.

ATOMIC TEST—Atomic tests are the firings of atomic bombs. They occur "naturally" in wars between groups of your sentient species.

Atomic tests do much damage, spread radiation, and put a lot of dust into the atmosphere. Too many atomic tests can cause a nuclear winter, which causes mass extinctions.

Areas that are contaminated by radiation are marked with this symbol.

Atomic tests are useful as a destructive tool, and for testing the effects of nuclear winter.

FIRE—Fires occur when the oxygen content of your atmosphere is too high. To protect against fires, keep your oxygen levels down.

Fires are useful for regulating the oxygen in your atmosphere, and causing general destruction.

EARTHQUAKE—A major shake-up of an area of the planet. When you point to the Trigger Earthquake option a sub-submenu will appear, allowing you to select the direction of energy expended by the earthquake. This will let you affect continental drift. Earthquakes under water will cause tidal waves.

When earthquakes appear naturally in SimEarth, they occur at plate boundaries (places where two land masses meet). To avoid damage from earthquakes, don't place cities near plate boundaries. To find these boundaries, look at the MAGMA display in the EDIT WINDOW. Wherever arrows that point in different directions are next to each other is a plate boundary.

In SimEarth, earthquakes are very useful events. You can use them to affect the movement of land masses, and change the magma flow. Forcing two land masses into movement toward each other is a fun way to create a mountain range.

To easily see the effect your earthquake has on the planet, turn on the MAGMA layer in the EDIT WINDOW before you trigger it, and watch the direction of the magma flow arrows change.

This is actually the opposite of what happens in the real world. We have reversed cause and effect. In reality, earthquakes are caused by the movement of the plate boundaries, and don't cause or change magma flow. It's not accurate, but it's a great tool for making mountain ranges.

PLAGUE—Plagues are very dangerous diseases that can wipe out entire cities, and will spread to nearby cities. They happen more often in low-technology areas, but once they happen there, they can spread to nearby high-technology areas.

To prevent plagues, you must invest in Medicine in the CIVILIZATION MODEL CONTROL PANEL.

Plagues aren't useful for anything but destruction.

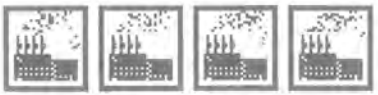
WAR—Wars cannot be triggered by the TRIGGER EVENTS icon. War in SimEarth represents battles between cities, as well as rebellions and revolutions within cities.

Wars are often caused by competition for resources such as fossil and atomic fuel. This is a self-regulating process: Cities grow too big, too close, and too fast for the local fuel supply; they go to war over the fuel; they kill enough of each other off so they can all live happily on the existing fuel; then they declare peace.

Sometimes wars just happen—SimEarthlings can be as stupid as Earthlings.

World wars occur in higher technology levels, and consist of lots of battles going on all over the planet.

The only way to prevent wars, or reduce the number and severity of wars, is by allocating energy to Philosophy in the CIVILIZATION MODEL CONTROL PANEL.



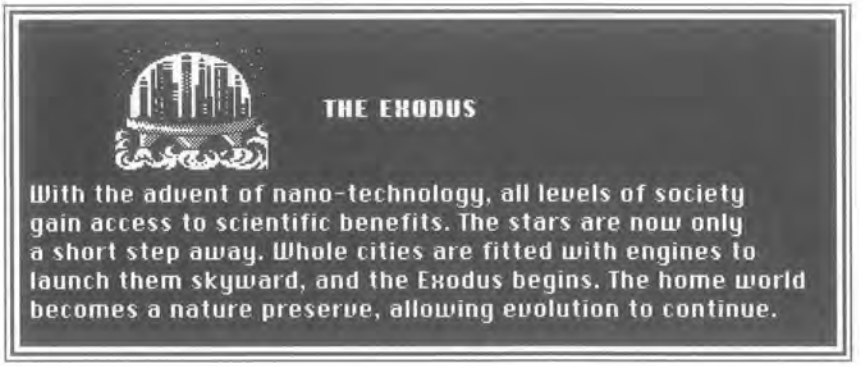
POLLUTION—Pollution events are warnings that the pollution in an area of your planet has reached levels that are dangerous to life.

They are primarily caused by industrial waste and pollutants, and can only be prevented and controlled by investing in non-polluting energy sources.

Pollution events cannot be triggered by the TRIGGER EVENTS tool, but if you want one, invest heavily in fossil fuels.

EXODUS—When the sentient SimEarthlings reach a high enough level of development, they leave the planet to colonize other worlds. The planet is then "retired" to the status of a wildlife preserve to be visited and cherished.

At this point, the planet returns to the Evolution Time Scale, and the race to sentience begins again.


THE EXODUS
With the advent of nano-technology, all levels of society gain access to scientific benefits. The stars are now only a short step away. Whole cities are fitted with engines to launch them skyward, and the Exodus begins. The home world becomes a nature preserve, allowing evolution to continue.

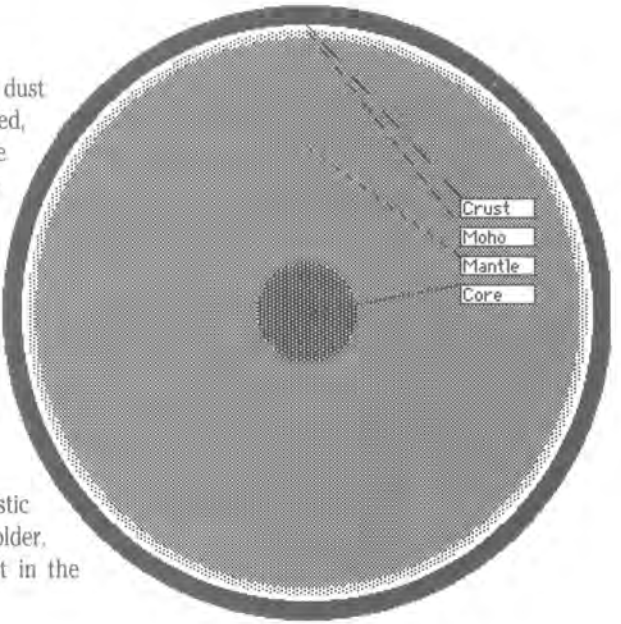
The EXODUS event is the closest thing in SimEarth to a "win condition."

GEOSPHERE

The Geosphere in SimEarth simulates planet formation, planetary cooling, continental drift, volcanic activity and erosion. For an explanation of geology and atmosphere of the real Earth, take a look at the Introduction to Earth Science section.

PLANET FORMATION

SimEarth simulates a planet just after interstellar dust has condensed into a lump of dirt. It is tightly packed, with a molten core. The surface is solid, but the surface temperature is still very hot. The atmosphere is mostly steam.



The flowing currents in the molten core cause parts of the solid surface of the planet to start moving around, crashing into each other. This crashing results in the creation of huge mountains and deep ditches.

PLANETARY COOLING

With time, the core of the planet solidifies to a plastic consistency, and gets larger as the planet gets older. The rate at which the core forms can be set in the GEOSPHERE MODEL CONTROL PANEL.

The larger the core, the smaller the magma layer. The smaller the magma layer, the slower the magma currents, and the slower the continental drift.

CONTINENTAL DRIFT

Continental drift is the movement of the solid crust of the planet on the liquid magma inside the planet. The faster and stronger the magma currents, the faster the drift. Continental drift is also affected by core heat. The rate of continental drift can be set in the GEOSPHERE MODEL CONTROL PANEL.

CORE HEAT

Core heat is the temperature of the planet's core. The higher the core heat, the larger and more severe the volcanos are. Also, the hotter the core, the more the direction of magma flow will change. Core heat can be adjusted in the GEOSPHERE MODEL CONTROL PANEL.

FORMATION OF THE OCEANS

The planet eventually cools enough for the steam in the atmosphere to condense and form oceans. Once oceans are formed, your planet is ready for life.

VOLCANIC ACTIVITY

Volcanos are vents in the surface of the planet that allow magma to flow to the surface. The volcanos in SimEarth are huge explosive events that make recent volcanic activities like Krakatoa look like pimples. When volcanos occur in water, they create islands. When they occur on land, they create great mountains. The frequency and violence of volcanos is directly affected by core heat.

You can also control the frequency and violence of volcanos with the GEOSPHERE MODEL CONTROL PANEL.

EROSION

Erosion is the "smoothing" of the terrain by wind and water. Younger planets will have higher, more jagged mountains than older planets that have suffered the effects of erosion longer. Erosion also creates large continental shelves. The rate of erosion can be set in the GEOSPHERE MODEL CONTROL PANEL.

Erosion increases the CO_2 level in the atmosphere.

ATMOSPHERE

The atmosphere in SimEarth consists of four gases—Nitrogen (N_2), Oxygen (O_2), Carbon Dioxide (CO_2) and Methane (CH_4)—plus water vapor (H_2O) and dust particles.

NITROGEN

Nitrogen is released by the soil through geochemical reactions with the air, and is absorbed into the soil by microbes. It is also released into the atmosphere by volcanos. It is the most common gas in the atmosphere.

OXYGEN

Oxygen is released into the atmosphere by plants and microbes during photosynthesis. It is consumed by animals and fires. Too little oxygen in the atmosphere (<15%) and animal life can't survive. Too much oxygen (>25%) and fires will break out all over the planet. Fires act as an oxygen regulator.

CARBON DIOXIDE

Carbon dioxide is released into the atmosphere by geochemical reactions and erosion, and is absorbed by plants and microbes. Too little carbon dioxide (<.1%) and plants can't survive. Carbon dioxide is a greenhouse gas, and will contribute to global warming due to the greenhouse effect. If your CO_2 level exceeds 1% you will have greenhouse warming.

METHANE

Methane is released into the atmosphere by bacteria (prokaryotes). It is a greenhouse gas, and will contribute to global warming through the greenhouse effect.

WATER VAPOR

Water vapor evaporates from warm oceans and lakes, and returns to the land and seas through rainfall. Water vapor in the atmosphere is increased by hurricanes and meteors hitting the oceans. Water vapor is a greenhouse gas.

DUST PARTICLES

Dust is released into the air by volcanic activity, fires, nuclear explosions, and meteor strikes. Too much dust in the atmosphere causes solar blockage, planetary cooling, and mass extinctions.

ATMOSPHERIC PRESSURE

Atmospheric pressure is a measure of how much atmosphere, by weight, is around the planet. The air pressure of the real Earth is 1.0 atmospheres. A higher atmospheric pressure allows a planet to better retain heat.

TRACKING THE ATMOSPHERE

You can keep track of your atmospheric composition by watching the ATMOSPHERIC COMPOSITION GRAPH.

CLIMATE

The climate of SimEarth is much simpler than on the real Earth. When modeling climate, SimEarth primarily takes into account air currents, air temperature, and rainfall.

Air currents, air temperature, and rainfall are influenced by sea temperature, ocean currents, solar input, cloud formation, cloud albedo, surface albedo, greenhouse effect, air-sea thermal transfer, and atmospheric pressure.

In addition, ice caps indirectly affect climate through their ability to cool the planet. Cold oceans are necessary for ice caps to form.

In SimEarth, as on the real Earth, the heat from the Sun is slowly increasing.

AIR CURRENTS
The planetary winds.

AIR TEMPERATURE
The average annual air temperature. The heat displayed here comes primarily from the sun, and secondarily from warm ocean areas.

RAINFALL
The amount of rainfall on the planet. It includes all types of precipitation.

SEA TEMPERATURE
The average annual ocean temperature. In most cases this will correspond closely with the air temperature, but it will change much more slowly.

OCEAN CURRENTS
The surface currents of the oceans.

SOLAR INPUT
The incoming solar radiation, also called *Insolation*. This is the amount of energy that reaches the planet from the sun.

CLOUD FORMATION
The amount of clouds formed from a given amount of evaporation.

CLOUD ALBEDO
The reflectivity of the clouds, which controls the amount of sunlight (heat) that passes through them to the planet.

SURFACE ALBEDO

The reflectivity of surface biomes, and therefore the amount of sunlight (heat) which is blocked by them.

GREENHOUSE EFFECT

The planet-warming greenhouse effect. The greenhouse effect is caused by certain gases that block outgoing infrared radiation. This keeps more of the Sun's heat in the atmosphere, which warms the whole planet. In SimEarth, the greenhouse gases are water vapor (H_2O), methane (CH_4), and carbon dioxide (CO_2).

AIR-SEA THERMAL TRANSFER

The rate at which the air and ocean can exchange heat

ATMOSPHERIC PRESSURE

A measure of how much atmosphere, by weight, is around the planet. The air pressure of the real Earth is 1.0 atmospheres. A higher atmospheric pressure allows a planet to better retain heat.

AFFECTING CLIMATE

You can affect the way SimEarth models climate by changing the settings on the ATMOSPHERE MODEL CONTROL PANEL.

LIFE AND EVOLUTION

As far as the model in SimEarth is concerned, life is any plant or animal on your planet.

The number and variety of plants, animals, niches and biomes included in SimEarth has been limited to enable the model to run on a home computer, but there are enough to demonstrate the principles involved with planet management.

ORIGINS OF LIFE IN SIMEARTH

In SimEarth, the only necessary factor for life to form is the presence of some deep sea (greater than 2500 meters deep) or ocean (between 1000 and 2500 meters deep). We assume the presence of all necessary chemicals and elements.

Ocean will form as soon as the planet cools, and if there is some deep ocean, life will form.

The formation of life on the real Earth is much more complicated, and still very controversial.

LIFE HAS FORMED
In the primordial soup the replicator is born. A molecule with the unique property of self-replication, the replicator begins making copies of itself. The thread of life begins.

LIFE IN SIMEARTH

Life in SimEarth is much simpler and less varied than on the real Earth. SimEarth has 15 classes of life, each with 16 species. The real Earth has millions of species.

SimEarth has seven biomes, the real Earth has many more.

EVOLUTION IN SIMEARTH

Evolution in SimEarth depends on many factors. For sea life to evolve, there must be shallow shelves. For land life, there must be the proper atmosphere, with enough carbon dioxide, oxygen, and air pressure. The air and water temperatures must be within livable limits. And there must be enough of the proper biome for the life to evolve in.

Life advances from simple to more complex forms, and, hopefully, to intelligence.

Evolutionary advancement also depends on population size. The more of a life-form you have on your planet, the more likely it is to advance to another level.

EVOLUTION TIME SCALE
The Invasion of Land - The Cambrian Era on earth saw a vast diversification of lifeforms, the beginning of the plant and animal kingdoms, and the first steps of life on land. Now you must survive periodic extinctions and promote intelligence to reach the Civilization time scale.

There are two sizes of steps SimEarthlings can take in their progress towards sentience: ADVANCEMENT and MUTATION.

ADVANCEMENT is a small step. It is a step up to a more complex species, but stays within the same class of life. The ADVANCEMENT RATE can be set in the BIOSPHERE MODEL CONTROL PANEL.

MUTATION RATE is a big step. It is a jump to a new class of life.

COMPETITION

There is competition within the evolutionary process. If two life-forms land on the same spot, the more advanced one will kill the other. The rating of which life-form is more advanced than another involves, among other smaller factors, the class, the species, and the IQ of each life-form. Some of these factors change over time and vary with the planet, so there can be no win/lose chart of life-form rankings.

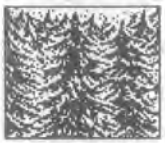
Also, if and when a new, higher class of life mutates, it will take precedence over all lower forms.

BIOMES IN SIMEARTH

There are seven available biomes in SimEarth, plus ROCK, which represents a lack of a biome in a location. To survive and spread, biomes require carbon dioxide and rainfall.

ROCK—No biome.

ARCTIC—Can survive in a cold and dry climate.



BOREAL FOREST—Can survive in cold temperatures, with moderate to high rainfall.

DESERT—Can survive in moderate to hot temperatures, with very little rainfall.

TEMPERATE GRASSLANDS—Can survive in areas with moderate temperatures and rainfall.

FOREST—Can survive with moderate temperatures and high rainfall.

JUNGLE—Can survive with high temperatures and rainfall.

SWAMP—Can survive with high temperatures and moderate rainfall.

BIOME PREFERENCE CHART

	DRY (<30 cm/yr)	MODERATE (30–90 cm/yr)	WET (>90 cm/yr)
COLD (<0° C)	Arctic	Boreal Forest	Boreal Forest
MODERATE (0–25° C)	Desert	Temp. Grasslands	Forest
HOT (>25° C)	Desert	Swamp	Jungle

Biome preferences are also influenced by altitude and the amount of CO_2 in the atmosphere.

LIFE-FORMS IN SIMEARTH

There are 15 classes of life represented in SimEarth; eight on land, seven in the sea. Only 14 of these are available in the PLACE LIFE tool. The 15th, the Carniferns—mobile, carnivorous plants that can evolve sapience—will sometimes appear through evolution.

Each class consists of 16 species. There are a total of 240 species in SimEarth. If a class of life reaches the 16th species, it becomes sentient. You will never see the 16th species of many of the classes unless you can help that class develop intelligence.

Below is an explanation of each class of life, with a graphic of all 16 species for that class of life. The possible evolutionary advancements and mutations are also shown. Advancement is in steps from left to right through all the species of that class. Mutation is a jump to a new class.

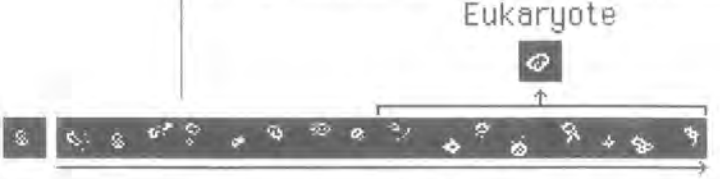
For each class of life below is a chart of its possible evolutionary paths. The progression of advancement within the same class, from simplest to most advanced (intelligent) is shown from left to right. Possible mutations to higher classes of life are shown as steps up.

Only certain species within a class of life can mutate. There are many evolutionary dead-ends.

SEA LIFE CLASSES

PROKARYOTE—Simple single-celled life that has no distinct nucleus, including bacteria and blue-green algae. Prokaryotes release methane into the atmosphere. In SimEarth, Prokaryotes are all treated as anaerobic, methane-consuming organisms, which is an extreme simplification.

The eight most advanced Prokaryote species can possibly mutate to Eukaryotes.

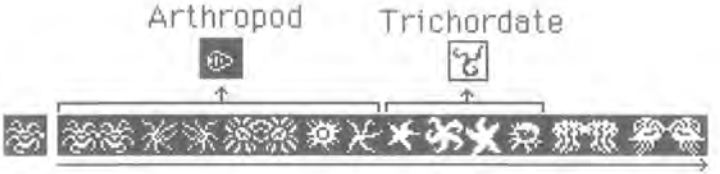


EUKARYOTE—Single-celled life with a nucleus; includes all single-celled life except prokaryotes. In SimEarth, all Eukaryotes are treated as aerobic, photosynthesizing organisms, which is an extreme simplification.

Eukaryotes evolve from Prokaryotes. The four most evolved species of Eukaryote can mutate into Radiates.

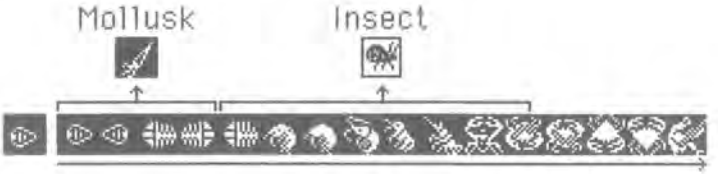
RADIATE—Simple, radially symmetrical multicellular life with definite tissue layers (three at most), but no distinct internal organs, head, or central nervous system. Includes jellyfish and sea anemones.

Radiates evolve from Eukaryotes. The first eight species of Radiate can mutate into Arthropods. The next four species can mutate into Trichordates.



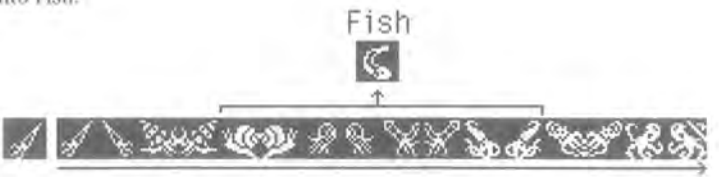
ARTHROPOD—Animals with jointed legs and a hard outer skeleton, including crabs, lobsters, and crayfish. (Spiders, scorpions, centipedes, millipedes, and insects are also arthropods, but they live on land.)

Arthropods evolve from Radiates. The first four species of Arthropod can mutate into Mollusks, the next eight can mutate into Insects.



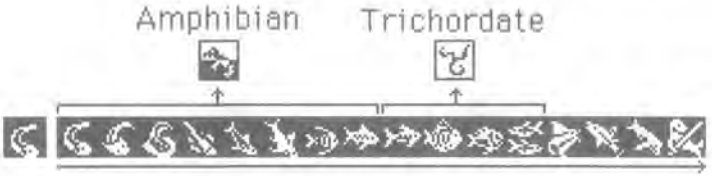
MOLLUSK—Fairly complex animals, most of which possess shells, including snails, clams, oysters, scallops, octopi, and squid.

Mollusks evolve from Arthropods. The middle eight species of Mollusks can mutate into Fish.



FISH—Very advanced and complex sea life with an internal bony skeleton.

Fish evolve from Mollusks. The first eight species of Fish can mutate into Amphibians, the next four species can mutate into Trichordates.



CETACEAN—Marine mammals with a highly developed nervous system, including whales, dolphins, and porpoises. Cetaceans can survive in Jungle biomes, as shown in the chart of Life Classes and Preferred Biomes. They actually live in the Jungle's rivers and tributaries that are too small to show in the EDIT WINDOW.

Cetaceans evolve from Mammals. The last four species of Cetacean can mutate back into Mammals.

LAND LIFE CLASSES

TRICHORDATE—Trichordates were a class of animal with three-chord spines. They lived and died out long ago on real Earth. We felt sorry for them, and are giving them a chance for survival in SimEarth.

Trichordates evolve from Radiates and/or Fish. They cannot mutate into anything else.

INSECT—The most numerous type of life on Earth, they have six legs and three body sections.

Insects evolve from Arthropods. Insects don't evolve into anything else, but, as shown in the chart, there is a co-evolution situation with Carniferns. The Carniferns don't actually evolve from Insects: they evolve from plants because of the presence of Insects.

AMPHIBIAN—Cold-blooded vertebrates somewhere between fish and reptiles, including frogs, toads, and newts.

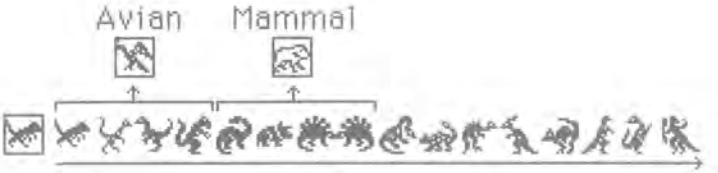
Amphibians evolve from Fish. The first eight species of Amphibians can mutate into Reptiles.

REPTILE—Cold-blooded vertebrates, including alligators, crocodiles, lizards, snakes, and turtles.

Reptiles evolve from Amphibians. The first eight species of Reptile can mutate into Dinosaurs. The next four species can mutate into Mammals.

DINOSAUR—Very big reptiles that long ago died out on real Earth. SimEarth gives them a new lease on life.

Dinosaurs evolve from Reptiles. The first four species of Dinosaurs can mutate into Avians. The next four species can mutate into Mammals.

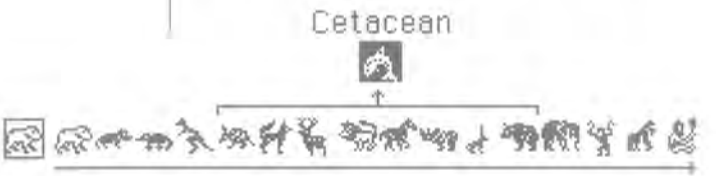


AVIAN—(A fancy word for bird.) Warm-blooded vertebrates with bodies more or less completely covered by feathers, with wings for forelimbs.

Avians evolve from Dinosaurs. Avians cannot mutate into anything else.

MAMMAL—The highest form of vertebrate, including man, apes, rodents, dogs, cats, etc. Mammals nourish their young with milk secreted from mammary glands, and have skin more or less covered with hair.

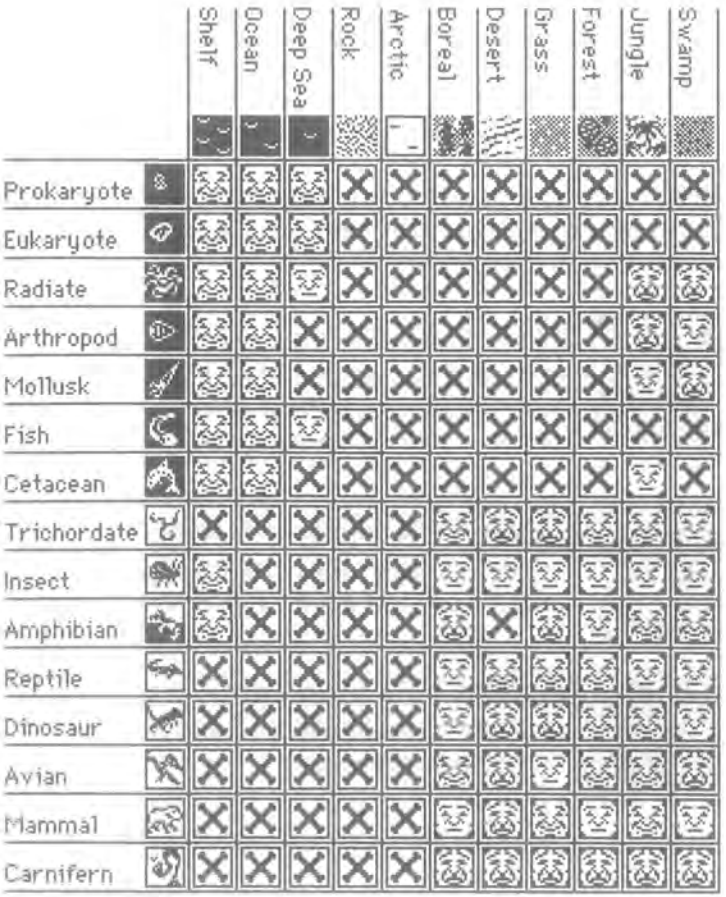
Mammals evolve from Cetaceans, Reptiles, and/or Dinosaurs. The middle eight species of Mammals can evolve into Cetaceans.



CARNIFERNS—Carniferns will evolve, but are not available to manually place with the PLACE LIFE tool. They are mobile, carnivorous plants that for simulation purposes are treated like animals. They are just above insects in evolutionary complexity, and evolved from plants taking advantage of insects as a food source. They can achieve intelligence, but it is rare.

Carniferns co-evolve with Insects. They actually evolve from plants, but their existence depends of the existence of Insects.

CHART OF LIFE CLASSES AND PREFERRED BIOMES



- Life class cannot exist here.
- Can exist here, but barely.
- Can exist here fairly well.
- Paradise.

CIVILIZATIONS IN SIMEARTH

There are seven levels of civilization represented in SimEarth, from the Stone Age of our past to the Nanotech Age of our future. For an in-depth look at these civilizations as they appeared on the real Earth, see the Introduction to Earth Science section of this manual.

Civilizations are represented by cities and travelling populations. Each city has three different population densities; the darker the city icon, the higher the population. Travelling populations represent expansion, communication and trade, and travel between cities.

The Nanotech age has four levels of density, and no travelling population. We assume they use transporters for trade and travel.

The advance of technology is a double-edged sword. Higher technology allows more efficient use of energy, shorter working weeks, and a higher quality of life. It also allows pollution, competition for fuel sources, wars, world wars, atomic wars, and other by-products of advanced civilization.

Below is a description of the civilizations in SimEarth with the graphics for the three (or four) levels of density and the travelling populations (if any), as they are displayed over land and over water.

STONE AGE—The Stone Age in SimEarth relates to civilizations on the real Earth thought to begin as far back as a million years ago, and lasting, in some places on the Earth, until today. It is characterized by the use of stone tools.

BRONZE AGE—The Bronze Age began with the regular use of metals for tools and weapons. The earliest established Bronze Age dates back to 3500 B.C. in the Middle East.

IRON AGE—The Iron Age began nearly 2000 years ago, and still exists in places today. It is characterized by the use of iron for tools and weapons.

INDUSTRIAL AGE—The Industrial Age in SimEarth relates to the time from the Industrial Revolution of the mid-18th century to the beginning of the Atomic Age. It is characterized by the use advanced tools and powered machinery.

ATOMIC AGE—The Atomic Age begins with the use of atomic energy. It is the present highest technology level on the real Earth.

INFORMATION AGE—The Information Age in SimEarth is the next technological step after the Atomic Age. In this age, information is the most important tool.

NANOTECH AGE—The ultimate level of technology in SimEarth is reached in the Nanotech Age. This is far enough in the future that we can only guess and dream about it. It will be characterized by a level of sophistication and technology that allows terraforming and colonizing other planets.

The Nanotech Age has four levels of density, and no travelling population. We assume they use transporters for trade and travel.

ALTERNATE INTELLIGENT SPECIES

SimEarth doesn't limit intelligent species to humans or even just mammals. Any class of life—other than Prokaryote and Eukaryote—can become intelligent.

Development of civilization in SimEarth requires land because of the need of fire, tools, and forges. Water creatures can be civilized, but need access to land for toolmaking.

In SimEarth, the most likely classes of life to evolve intelligence are: reptiles, dinosaurs, birds, and mammals.

The next most likely group are: cetaceans, insects, amphibians, and carniferns.

The least likely to evolve intelligence are: radiates, mollusks, arthropods and fish.

Aside from the above ranking, the evolution of intelligence is influenced by the amount of the proper biome for a species on the planet. Also, if an evolutionarily higher form of life appears, it will have an advantage over an advanced lower form of life.

All intelligent, sentient SimEarthlings act very much like humans in development of civilization, cities, industry, etc.

THE MONOLITH

The Monolith is a tool to help accelerate the advancement of intelligent species. It is an Evolution Speed-up Device (our thanks to Arthur C. Clark). Once you select the Monolith, if you click on a life-form, there is a one-in-three chance of that life-form suddenly mutating to a higher level, which immediately moves you to the next Time Scale. The Monolith won't work on all the animals. If you try to use the Monolith on the wrong animal, the program will beep at you, but there will be no energy charge. It costs 2500 E.U. to use a Monolith—whether or not it works.

A disadvantage to using the Monolith is that you could jump ahead into the civilization Time Scale before enough fossil fuels have been generated, and civilization will collapse. You need a wide population base to advance to the next technology level. Don't rush to a new Time Scale at the expense of your population.

INFLUENCING CIVILIZATION

The main way you influence your sentient life-forms is by telling them what energy sources to invest in, and how to allocate the energy. This is done through the CIVILIZATION MODEL CONTROL PANEL.

ENERGY

In SimEarth there are two uses of energy. You, the player, use it to make, mold, modify and manipulate the planet, and civilized SimEarthlings make and use it to carry on their daily lives.

The energy in SimEarth is measured in Energy Units, or E.U. The symbol Ω is used in the program as the symbol for an Energy Unit.

Intelligent SimEarthlings will produce and use energy. You can control their choice of energy sources and their use of the energy they produce, but you don't have *direct* access to *their* energy for *your* purposes.

Depending on the difficulty level of the game, you will have different amounts of energy to affect the planet and the simulation. These amounts are both your starting supply and the maximum you can accumulate at any one time.

If you are in experimental mode, you will have an unlimited supply of energy.

EXPERIMENTAL MODE	Unlimited Energy
EASY GAME	5000 E.U.
MEDIUM GAME	2000 E.U.
HARD GAME	2000 E.U.

Energy for a game comes from the stores of the planet itself in the form of geothermal, wind, and solar energy, as well as fossil fuels. As you deplete your energy supplies during a game, it will slowly build back up over time as the planet increases its energy from the above sources. This continual tapping of the planet's energies happens automatically.

The amount of energy you have to use is displayed in the EDIT WINDOW in the AVAILABLE ENERGY DISPLAY.

Your energy reserves are depleted by every action you take that affects the planet or simulation. New energy becomes available on the planet through time from various sources explained below. You can tap some of this new energy. It will automatically be added to your available energy each Time/Simulation cycle.

As technology develops, your sentient SimEarthlings generate energy for their own use. As technology on the planet advances, they generate more energy more efficiently.

You don't have direct access to the SimEarthlings' energy, but some of it will be automatically tapped and added to your reserves. The amount of energy automatically added to your reserves each Time/Simulation cycle increases with the increasing level of technology on your planet. The rate at which your energy reserves increase is as follows:

GEOLOGIC TIME SCALE		1 E.U. per cycle
EVOLUTION TIME SCALE		1 E.U. per cycle
CIVILIZATION TIME SCALE	Stone Age	2 E.U. per cycle
	Bronze Age	3 E.U. per cycle
	Iron Age	4 E.U. per cycle
TECHNOLOGY TIME SCALE	Industrial Age	5 E.U. per cycle
	Atomic Age	6 E.U. per cycle
	Information Age	7 E.U. per cycle
	Nanotech Age	8 E.U. per cycle

SOURCES OF ENERGY

There are five sources of energy in SimEarth.

BIOENERGY—Burning wood, animal power, plant power (farming), and work done by hand by the sentient species. Bioenergy gets more efficient through time because of better, more efficient farming tools, and scientific breakthroughs such as recycling biowaste into fuel. Using bioenergy releases CO_2 into the atmosphere, so it has a minor polluting effect.

SOLAR/WIND—Sun-drying of food and clothes, windmills, sailing ships, solar heating, wind-powered generators, solar electric cells, and satellites collecting solar energy. Improves in efficiency as technology advances.

HYDRO/GEO—Waterwheels, dams, steam power, hydroelectric power, and geothermal power. Improves in efficiency as technology advances.

FOSSIL FUEL—Coal made from long-dead animals. A by-product of burning fossil fuels is the release of greenhouse gases into the atmosphere.

NUCLEAR—Atomic reactors, bombs, etc. Atomic explosions release dust and radiation into the atmosphere.

ENERGY COSTS

There is no free lunch in SimEarth, and the price you pay for everything is energy. Here is the price list.

PLACE PROKARYOTE	35	E.U.
PLACE EUKARYOTE	70	E.U.
PLACE RADIATE	105	E.U.
PLACE ARTHROPOD	140	E.U.
PLACE MOLLUSK	175	E.U.
PLACE FISH	210	E.U.
PLACE CETACEAN	245	E.U.
PLACE TRICHORDATE	280	E.U.
PLACE INSECT	315	E.U.
PLACE AMPHIBIAN	350	E.U.
PLACE REPTILE	385	E.U.
PLACE DINOSAUR	420	E.U.
PLACE AVIAN	455	E.U.
PLACE MAMMAL	490	E.U.
PLACE STONE AGE	500	E.U.
PLACE BRONZE AGE	1000	E.U.
PLACE IRON AGE	1500	E.U.
PLACE INDUSTRIAL AGE	2000	E.U.
PLACE ATOMIC AGE	2500	E.U.
PLACE INFORMATION AGE	3000	E.U.
PLACE NANOTECH AGE	3500	E.U.
PLACE BIOME FACTORY	500	E.U.
PLACE OXYGENATOR	500	E.U.
PLACE NO_2 GENERATOR	500	E.U.
PLACE VAPORATOR	500	E.U.
PLACE CO_2 GENERATOR	500	E.U.
PLACE MONOLITH	2500	E.U.
PLACE ICE METEOR	500	E.U.
TRIGGER ANY EVENT	50	E.U.
PLANT ANY BIOME	50	E.U.
SET ALTITUDE	50	E.U.
MOVE ANYTHING	30	E.U.
EXAMINE ANYTHING	5	E.U.
CHANGE CONTROL PANEL	30	E.U. per click
	150	E.U. per drag

SIMULATION FLOW CHART

Inside the back cover of this manual is a flowchart that describes the inner workings of the SimEarth program.

Referring to this chart will be useful for solving problems and understanding what the simulation does and why it does it.

AN INTRODUCTION TO EARTH SCIENCE

"The performance of a Prokaryote is far superior to that of an Amateurkaryote."

Maxwell Maxis

SimEarth

INTRODUCTION

SimEarth is a computer simulation of the Earth as a living system, developed in the spirit of James Lovelock's Gaia hypothesis. To get the most out of SimEarth, a little background in earth science is necessary.

This section of the manual is a primer to give you a start in understanding how our planet works. You will become familiar with many cause and effect relationships that are key to the dynamic play you will experience in SimEarth.

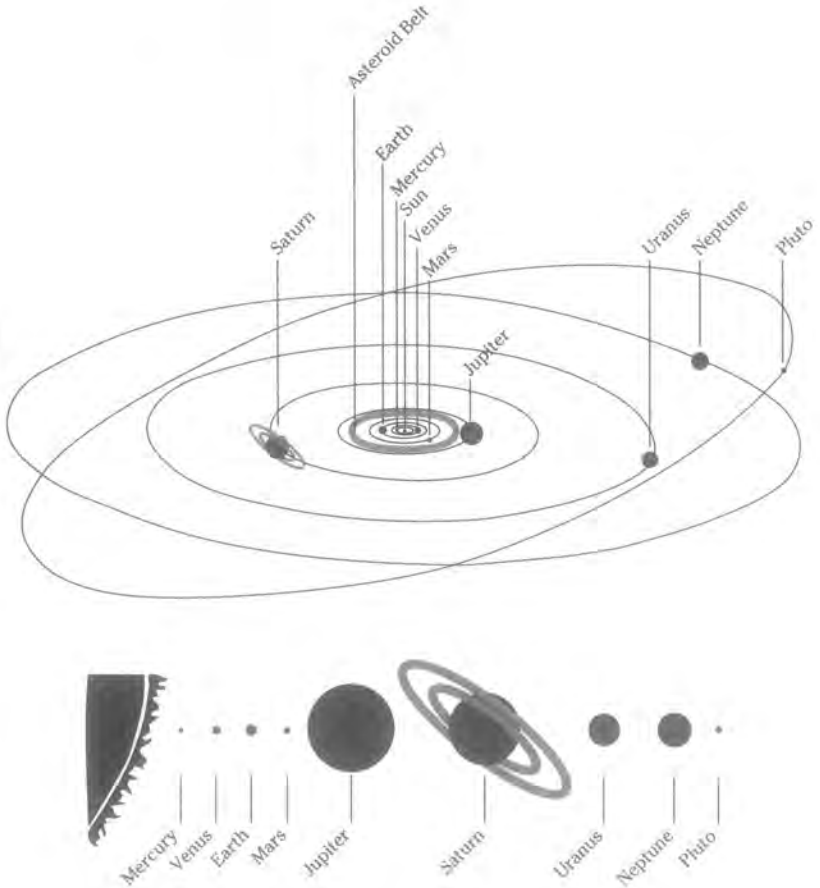


Figure 1 Our Solar System

EARTH AND THE OTHER PLANETS

In the last 30 years, more than 200 men and women from 18 nations have traveled in space and looked back at earth. These astronauts took beautiful pictures that provide a new look at our planet.

The view of Earth from space is having a deep impact on our culture: it is changing the way we look at our world and our place in it. It is a surprising view for those who came from a Western scientific background in which the study of the Earth was divided up into separate segments, and the Earth was viewed as a "dead" planet.

Earth science is a relatively recent approach to looking at our planet. It encompasses all the other sciences focused on understanding the Earth. It involves physics, chemistry, biology, astronomy, psychology, sociology and other areas of research. James Lovelock's Gaia hypothesis provides a framework for us to view the planet as a living system.

Earth is different from every other planet in our solar system.

Earth is the biggest of the four inner planets (Figure 1). It is the only planet with an atmosphere suitable for oxygen-breathing life. The Earth also has the biggest moon in proportion to its size in the Solar System: so big that some think we are a two-planet system.

No other planet (that we know of) has plate tectonics, a dynamic atmosphere and a hydrosphere. No other planet has an atmospheric composition like ours, nor the systems of life we have in our biosphere. This is not to say that other planets have no life in the broadest sense of the word, but not as we know it on Earth.

Earth scientists divide the earth into four interrelated components:

the **Lithosphere**—The solid, rocky part of the Earth: continents and ocean floor;
the **Hydrosphere**—the liquid part of the Earth: oceans, lakes and rivers;
the **Atmosphere**—the gaseous part of the Earth: air and clouds; and
the **Biosphere**—the living part of the Earth: humans, plants and animals.

Mercury is the closest planet to the Sun and so small that the light gases such as oxygen (O_2) and carbon dioxide (CO_2) evaporated during the planet's formation.

Venus has so much carbon dioxide (CO_2) that its surface temperature is more than 700° C—what is usually known as a runaway greenhouse effect. Venus probably had some plate tectonics in the past, but no longer.

Mars definitely had plate tectonics, volcanos, and mountains in the past, but being smaller than the Earth, it cooled more rapidly and is now geologically dead. The Martian atmosphere is so thin it would be impossible for humans to survive in it.

The rest of the Solar System, which includes Jupiter, Neptune, Saturn, Uranus and Pluto, are either so large or so far away from the Sun that they are too cold for life. They are mostly gaseous, unlike the rocky, solid inner planets.

ABOUT THIS INTRODUCTION TO EARTH SCIENCE

This Introduction to Earth Science is presented in five sections:

Geology (Lithosphere)
Climate (Atmosphere and Hydrosphere)
Life (Biosphere)
Humans and Civilizations (Biosphere)
Theories of the Earth

GEOLOGY

This section deals with the Lithosphere—the solid rocky part of the Earth. It covers the following subjects:

- the Origin of the Earth;
- the Evolution of the Earth;
- the Composition and Structure of the Earth;
- Special Characteristics of the Earth; and
- the Divisions of the Earth.

THE ORIGIN OF THE EARTH

How did our solar system come into existence? Scientists currently lean towards the **solar nebula hypothesis**.

This hypothesis states the following series of events:

A primordial cloud of gas and dust, called a nebula, once rotated in space.
The gravitational attraction of the material inside the nebula caused contraction of the primordial cloud, speeding up its rotation.
The shape changed to that of a flattened disk as a consequence of the increased rotation.
Matter then migrated towards the center, and formed what is called a **proto-Sun**.
The formation of the proto-Sun and the possible explosion of a nearby supernova caused the collapse of the nebula and triggered the formation of the solar system.
The collapse increased the temperature of the proto-Sun due to a thermonuclear chain reaction (high-temperature fusion of hydrogen atoms to form helium atoms).
The proto-Sun started to shine.
Matter began to form out of the material in space.
The hot proto-Sun and the surrounding gas and dust that still remained after the collapse began cooling down.
Gaseous material started to condense.
Small chunks of matter called planetesimals clumped together.
The biggest ones pulled most of the matter due to their higher gravitational attraction. If the **planetesimals** were too close to the Sun the lightest materials (hydrogen, helium, etc.) were blown away by the Sun's wind.
The planetesimals closest to the Sun were also composed of the densest materials (the ones with the highest melting points), like

iron. A good example is Mercury, with a density more than five times the density of water.

As the planetesimals got farther away from the Sun and therefore colder, lighter materials, such as silicon and oxygen, condensed and formed the rocky silicate planets (Venus, Mars, Earth).

The biggest and farthest-away planetesimals, which eventually became the giant planets Jupiter and Saturn, were able to retain the very light compounds such as hydrogen, methane and ammonia.

This hypothesis, although not completely tested, explains the basics of planetary formation and gives us the background to develop hypotheses for the evolution of the Earth from a condensed, homogeneous planetesimal to the differentiated, layered medium it is now.

THE EVOLUTION OF THE EARTH

THE FIRST BILLION YEARS

Age-dating of meteorites and the oldest rocks on the planet tell us that the oldest solid rocks on the Earth are about four billion years old, and that the Earth is about 4.7 billion years old.

Five billion years ago, what was later to become the Earth was a homogeneous conglomeration of silicon compounds, some iron, magnesium, and oxygen compounds, and smaller amounts of the other elements.

The pre-Earth was not as large as the planet we know today. It grew to its present size by the gradual addition of other planetesimals and meteorite bombardment.

The continuous bombardment not only increased the size of the planet, but it also heated it up. The rise in temperature due to impacts and gravitational compression, linked with the radioactive decay of heavy elements (which also produces heat), most likely partially melted the primordial Earth. The partially molten Earth was then affected by what is known as the **iron catastrophe**, which then led to the formation of the core.

FORMATION OF THE EARTH'S CORE

Within the partially molten primordial Earth, iron droplets, denser than the surrounding liquid, started falling towards the center of the planet forming a liquid iron core. Other dense elements (such as nickel and gold) followed. Since then, the Earth's core has been composed mainly of iron and nickel. Initially all liquid, it has slowly cooled from the center out, so that the Earth now has both an inner solid core and outer liquid core. The outer core, being liquid and very hot, convects (like boiling water in a pan), which generates the Earth's unique

and strong magnetic field. The accumulation of iron at the center of the Earth released a large amount of energy that caused the rest of the Earth to melt.

DIFFERENTIATION AND THE FORMATION OF THE ATMOSPHERE AND OCEANS

The Earth, now almost completely molten, began a period of rapid differentiation.

The molten material, lighter than its surrounding solid parent, rose to the surface of the Earth and formed a primitive crust. It later separated into the lighter continental crust and the denser oceanic crust. The material left between the dense iron core in the center and the crust became the mantle.

Differentiation was also responsible for the initial escape of gases from the interior, called **outgassing**, which eventually led to the formation of the atmosphere and oceans.

COMPOSITION AND STRUCTURE OF THE EARTH

Earth is made up of three main layers: the crust, the mantle and the core, as shown in Figures 2A and B.

CRUST

The **crust** is the uppermost layer of the Earth. There are two types of crust: **oceanic**, made of basalt, and **continental**, composed mostly of granite. Oceanic rock is dense, has deep trenches and varies from six to ten kilometers in thickness (the Marianas in the Pacific and the Puerto Rico trench in the Atlantic). Continental crust is 35 kilometers thick on average. The crust is rigid and elastic at the same time.

MANTLE

The **mantle** is divided into several layers and is separated from the crust by a discontinuity, or break, called the **Mohorovicic** ("Moho," for short). The **uppermost mantle** extends for approximately 100 km under the **Moho**, below the oceanic and continental crust. This part of the mantle is composed of mainly two minerals (olivine and pyroxene),

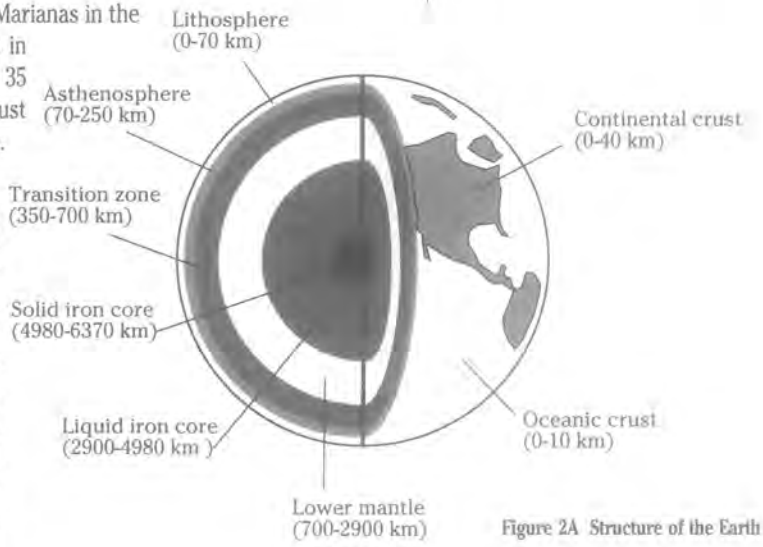


Figure 2A Structure of the Earth

and has the same rheological (deforming) properties as the crust: it is both rigid and elastic.

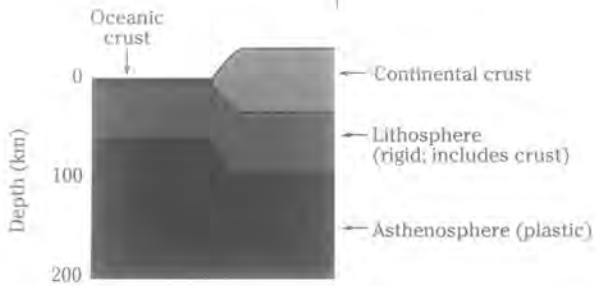


Figure 2B Structure of the Crust

Because they have the same rheological properties, the crust and uppermost mantle behave in unity.

Together, the crust and uppermost mantle comprise the **lithosphere,** which reaches down as far as 150 km below the surface. Surface **plate tectonics**, which are described later in the manual, explain the behavior of the lithosphere.

Below the lithosphere is the **asthenosphere**. This layer extends to a depth of 300 km below the surface of the earth.

Composed of the same materials as the uppermost mantle, the asthenosphere is considered a separate layer from the lithosphere because it behaves differently. The asthenosphere is hotter, weaker, and **plastic**: it deforms permanently under pressure. The hotter a material gets the less elastic and more plastic it becomes.

To give you an example with everyday materials, let's use a rubber band and toffee. An elastic rubber band stretches to a certain limit and then it breaks—a sudden, clean break. If we release it before it breaks it will go back to its original form. Toffee, on the other hand, will deform plastically under the same forces. If you pull on it, it stretches just like the rubber band, but if you release it before it breaks it will stay stretched or deformed; it will not bounce back to its original shape. The lithosphere acts like the rubber band, the asthenosphere like the toffee.

Below the asthenosphere is the **transition zone**, the area between 300 and 700 km beneath the surface. The transition zone, although hotter than the asthenosphere, is not partially molten.

The transition zone gets its name from the fact that the minerals (mainly olivine and pyroxene, but also some garnet) transform to denser forms within this region due to heat and pressure. They reach their most dense possible structure at 700 km, the boundary between the upper mantle (lithosphere, asthenosphere and transition zone) and the **lower mantle**.

The lower mantle extends from 700 km to 2700 km below the surface of the Earth. From 2700 to 2900 km is another transition region that separates the mantle and the core.

CORE

The center of the Earth is called the **core** and has two layers. The outer core, comprised of iron and nickel, extends from 2900 to 5120 km beneath the surface. The outer core is liquid and hot. The motion of the fluid in this region generates the Earth's unique and strong magnetic field.

The inner core begins at 5120 km and extends to the center of the Earth, 6400 km below the surface. The temperature at the center of the Earth is about 10,000° C—hotter than the surface of the Sun.

SPECIAL CHARACTERISTICS OF THE EARTH

The Earth possesses unique characteristics that separate it from the rest of the planets: a powerful magnetic field, the presence of plate tectonics which have changed the surface structure significantly over time, and the existence of an atmosphere, oceans and life.

MAGNETIC FIELD

By slow convective movements in the liquid iron core, electric currents are produced in the core which generate and maintain the Earth's magnetic field.

The magnetic field is what enables us to navigate the seas or find our way through a deep forest by using a compass. In simple terms, the Earth's magnetic field can be described as a giant magnet with North and South poles. The North magnetic pole coincides with the geographic North pole.

At certain points in time, the magnetic field reverses—the magnetic North becomes South and magnetic South becomes North. By examining very old rocks with magnetic minerals that preserve the orientation of the magnetic field at the time they formed, geologists have been able to construct the **magnetic polarity time scale**, key in the development of the theory of **sea-floor spreading** and plate tectonics. The last magnetic field reversal was over a million years ago.

PLATE TECTONICS AND CONVECTION

The Earth is also unique in that its surface layer, the lithosphere, is broken up into pieces, or plates, that move and deform. The movement and deformation of the plates—plate tectonics—is responsible for mountain building, earthquakes nd volcanos. There are 12 major plates on the planet, illustrated in Figure 3.

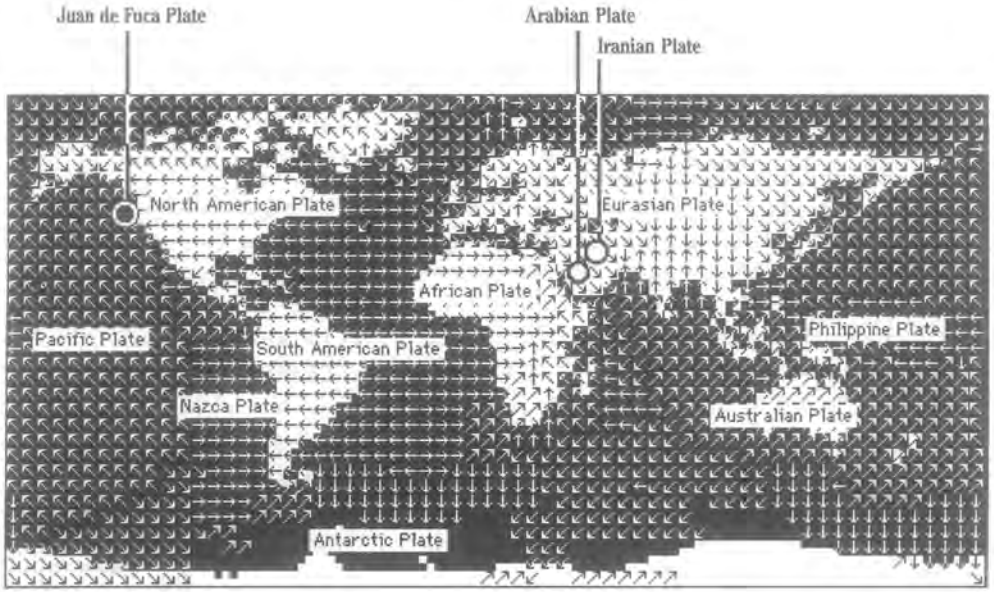


Figure 3 Tectonic Map of the Earth's Surface

The plates move in response to the convection of the mantle underneath. Convection is a mechanism of heat transfer in which hot material from the bottom rises to the top (hotter material is less dense and therefore weighs less), and the cooler surface material sinks. Convection is the most effective form of heat transport.

ATMOSPHERE, OCEANS, AND LIFE

Another important characteristic of the Earth is its fluid sphere: the atmosphere and oceans. Earth is the only planet in which two-thirds of the surface is covered by water, and is surrounded by an atmosphere composed mostly of oxygen and nitrogen. These two features have enabled the Earth to develop an amazing variety of living organisms.

There are many theories for the origin of the atmosphere and oceans. The most widely accepted theory states that in the Earth's earliest beginnings, it had no gaseous atmosphere. It was too small, and didn't have enough gravity to retain the lighter gaseous elements that existed at that time.

As time passed, the Earth increased in size and mass: large meteorites ar planetesimals added their mass by crashing into the Earth, and the Ear

gravity attracted smaller particles of matter. Eventually, Earth was big enough to retain an atmosphere.

The original atmospheric gases (very different from today's oxygen-nitrogen atmosphere) must have been produced by outgassing (the escape of gases from within the solid planetary mass) during the initial differentiation.

This early atmosphere must have had a similar composition to the gases released during volcanic eruptions today, and consisted of water vapor, hydrogen, hydrogen chlorides, carbon dioxide and monoxide, and nitrogen. The light hydrogen compounds could not and cannot be held by Earth's gravity, and so they must have escaped away as they do today. As the planet cooled, the water vapor in the atmosphere condensed into the water that formed the oceans.

The present atmospheric composition was achieved later by several chemical reactions and the evolution of life.

INFLUENCE OF THE SUN AND MOON

The presence of the Moon has one major visible effect on the Earth: most notably, the behavior of the oceans in the form of tides. The gravitational pull of the Moon and the Sun on the Earth causes the sea level to alternately rise and fall during the day. Gravitational effects are observed in both the oceans and the solid Earth, though the latter can only be detected by very sensitive instruments.

The tides in the water can be seen and measured accurately and the time of occurrence calculated. The side of the Earth facing the Moon feels the strongest tide and the side opposite to it feels the minimum tide. As the Earth rotates, the tides move around it. The Sun, although farther away, is so large that it has the same effect. Solar tides are half the height of lunar tides, and are not in phase with lunar tides. Solar tides occur every 24 hours; lunar tides occur every six (high, low, high, low).

Moon and Sun line up the tides are very strong. These are called spring ti... ...y occur every two weeks, at full and new Moon. When the Moon and the Su... ...t right angles to each other with respect to the Earth we have the lowest tides, known as neap tides, which occur between first- and third-quarter moons.

Tides cause loss of energy through friction between the water and the sea floor. The energy loss is enough to slow down the rotation of the Earth by a very small amount. This effectively lengthens the day. All these patterns are shown in Figure 4.

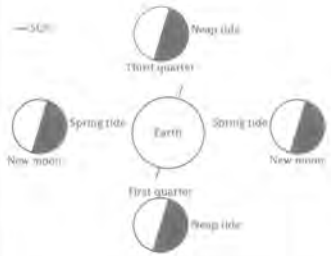


Figure 4A Tides

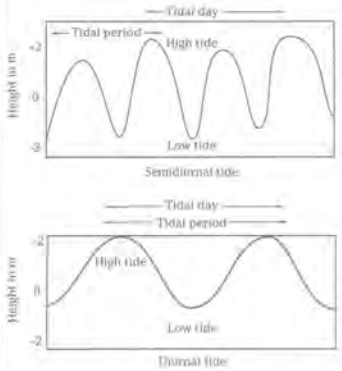


Figure 4B

DIVISIONS OF THE EARTH

We can summarize the behavior of the Earth in a fairly concise way by dividing its processes in two: surface processes of the external heat engine and internal processes of the internal heat engine.

A heat engine is a mechanism that converts high-temperature heat (energy) into work. It is composed of four main "parts":

1) High T (temperature) source;
2) Working fluid;
3) Work to be done; and
4) Low T sink (something that cools by absorbing heat).

These parts in the internal and external heat engines are identified below.

	EXTERNAL HEAT ENGINE	INTERNAL HEAT ENGINE
SOURCE	Radiation from the Sun	Heat from radioactive decay Latent heat from fusion of the core
WORKING FLUID	Atmosphere and oceans	Mantle rocks
WORK	Erosion, weathering, etc.	Plate tectonics
SINK	Outer space	Outer space

EXTERNAL HEAT ENGINE

Many of the surface processes of the Earth are the direct result of the work done by the external heat engine. These processes are what determine many, but not all, of the short- and long-term changes in the Earth's landscape.

The processes that occur within the external heat engine can be classified into four groups:

Erosion: the set of processes that results in the loosening of soil and rock, as well as its removal downhill or downwind.

Weathering: the set of processes, chemical or physical, that results in the breakup and decay of bedrock. Of the four processes, this is now the most important for human concerns.Weathering breaks up and chemically changes bedrock, transforming it into soil essential for agriculture. Our abusive agricultural system is eroding good soil at a rate faster than it can be created by weathering.

Transportation: the set of processes involved in moving loosened material from one place to another.

Deposition: the set of processes resulting in the settling down of the transported sediment.

These four processes are carried out by three main agents: **wind**, **water** and **glaciers**.

WIND

Wind is an important agent of erosion and deposition. In deserts, for example, all the erosion, transportation and deposition of sand is exclusively carried out by winds. Normal winds can only carry very small particles, but strong winds, as in the Sahara sandstorms, can carry a markedly heavier load.

WATER

Water in its fluid form is the most important agent of erosion, transport and deposition on the surface of the Earth. Water is also important in chemical and physical weathering as it is the fluid that enables many of the chemical reactions that break down bedrock; it also enlarges cracks in the freezing and thawing processes.

Water causes erosion of soil by runoff after heavy rain, in river channels from the head to the mouth (mostly at the head), and by ocean currents both along coasts and on the bottom of the ocean. Water in rivers is extremely important in shaping the landscape, i.e., the Grand Canyon and the Colorado River.

Transport of sediments by water occurs in runoff channels, in rivers and in currents in the ocean or along the shore.

Water allows deposition of sediment in river channels and deltas. Deposition by water is very clearly seen in the inside part of the curves of rivers, in deltas, and also in the ocean bottom as a river enters the ocean and dumps its sediment load on the bigger body of water.

Water reservoirs on land are rivers, groundwater and lakes. Glaciers are also a reservoir of water, but they will be treated separately.

GLACIERS

Large bodies of water accumulated as ice are usually known as glaciers. There are several types of glaciers: mountain glaciers like those that covered Yosemite in California, continent-sized glaciers known as ice-sheets like those in Greenland or Antarctica, and others.

Glaciers are a very powerful and rapid agent of erosion, transport and deposition. Glaciers can carve a valley in a shorter time scale than any river. They can transport sediment that ranges from sand grains to boulders the size of a house.

Glacier landscapes are recognized by their U-shaped valleys, while river valleys are V-shaped. The valley floors have striations caused by the boulders scraping the bedrock, and the sides and end of the valley have an assortment of rock sizes we generally call moraines.

OTHER SURFACE PROCESSES

Two hot topics of public debate are the processes and effects of **global warming** and **air pollution**. The following section will lend insight into these topics as we discuss the basics of the **carbon cycle** and **element transport** by rivers to the oceans.

THE CARBON CYCLE

Carbon dioxide (CO_2) is used by **photosynthetic** organisms (organisms that make their own food) such as plants, to generate the complex carbohydrates and the energy they need for survival. In this process the carbon is locked up in complex molecules and oxygen is returned to the atmosphere.

Non-photosynthetic organisms such as humans and other animals breathe oxygen and give back CO_2 to the atmosphere. When either type of organism dies, the organic matter decays and the carbon in the complex molecules is released generally in the form of CO_2.

Carbon also accumulates to form fossil fuels that humans have learned to use. Such burning of the carbon in these fuels releases additional CO_2 into the atmosphere, causing an unbalance or destabilization in the natural equilibrium of the atmosphere/biosphere dynamic relationship.

Cutting down forests or plants also creates a destabilization of the environment, because it results in less photosynthesis. As a result, less CO_2 is consumed and less oxygen is produced.

The highest reservoir of carbon is found in rocks, especially in limestone. The carbon is trapped in the limestone when marine organisms, whose shells are made of calcite, die and fall to the bottom of the ocean and accumulate into thick layers. When the layers compact and harden they become limestone. Most of the carbon stays there until the ocean floor, and the limestone with it, is consumed through earthquake and volcanic activity. Then the limestone melts and the

carbon in the form of CO_2 gas is released through volcanos and returned to the atmosphere.

The processes of weathering and erosion cause many elements trapped in minerals to be transported back to the oceans, where they interact with both the oceanic water and rocks.

For the purposes of studying the Earth, we need to know how these elements are transported back to the oceans and how long they interact with water before being trapped in minerals. This helps us understand mountain-building activity, the measure of erosion rates, and how rock/water interactions and basalt composition form the oceans.

For environmental reasons, knowledge of these processes is equally important. It teaches us about the behavior of toxic or radioactive elements in the ocean that occur, for example, as a result of disasters such as major oil spills. It also helps us understand the effects of increased CO_2 in the atmosphere, which occurs as a result of the burning of fossil fuels by an ever-increasing population.

INTERNAL HEAT ENGINE— PLATE TECTONICS

The most outstanding achievement of the Earth sciences in all its history was the advent of the theory of plate tectonics in the 1960s, which, with a few simple geometrical arguments, has organized and explained the large-scale processes of the surface of the Earth.

Plate tectonics is the work done by the internal heat engine.

HISTORY

Early in the 1600s Sir Francis Bacon had already noticed the jigsaw-puzzle features of the early maps produced by the explorers of the New World. Later, Antonio Snider and Edouard Suess proposed the existence of a giant supercontinent, but it was not until the late 1920s, 100 years after their first publication, that a hypothesis explaining these features was proposed.

In 1929, Alfred Wegener, a meteorologist, proposed the Continental Drift hypothesis. Wegener collected paleontological data on fossil plants and animals in the Old and New worlds, as well as other geological evidence (structures, rock types and ages across the equatorial Atlantic) and proposed the existence of a giant supercontinent that broke into the present continents 200 million years ago. He named this continent **Pangaea**.

Wegener's hypothesis was dismissed after 10 years because he failed to present a valid mechanism that would satisfy the physicists and geophysicists of the time. Ironically, 60 years later, continental drift and plate tectonics are accepted as the ruling paradigm of the earth sciences, but there still isn't a clear idea of the mechanism that causes it.

Continental drift and plate tectonics were finally accepted in the 1960s after several geologists and geophysicists presented incontrovertible evidence of sea-floor spreading, ocean consumption and transform motions.

PLATE TECTONICS

In simple terms, the earth's surface is not continuous and static, but broken into pieces like a giant jigsaw puzzle. Those pieces can be continental or oceanic. They move due to flow in the mantle underneath the surface. With this simple explanation, plate tectonics was used to explain the distribution and nature of volcanos around the Pacific Ring of Fire and also the distribution of earthquakes all around the world.

Plate tectonics is the theory that explains how the lithosphere is broken into pieces called spherical caps that are internally rigid and change in limited amounts only at boundaries. Three types of boundaries exist: divergent (mid-ocean ridges), convergent (subduction zones), and transform (faults). The caps move at constant velocities which are continually being determined by the convection in the mantle.

Before we explain the three different types of boundaries, or margins, what follows is an explanation of volcanos and earthquakes.

VOLCANOS

A volcano is a land edifice that is slowly built up by the eruption of hot molten rock (**magma**) on the surface of the Earth. The erupted rocks, made up of many different compositions (cooled magma) are called volcanic. If the molten rocks don't reach the surface, but cool under the volcano, they are called plutonic.

The hot magma flowing on the surface is called lava. Volcanos can be of very different types depending on the composition of the rocks. The composition determines if the volcanos will erupt quietly (Kilauea, Hawaii) or violently (Mt. Saint Helens, Washington).

Volcanos occur at two plate boundaries and also in the middle of plates. When associated with convergent boundaries, they are usually violent; when divergent they are under water and erupt quietly. Intra-plate volcanos are often associated

with hot-spots in the bottom of the mantle that produce chains of volcanos such as we find in Hawaii. These are usually quiet volcanos.

Knowing the plate boundaries is important in predicting which type of eruption will occur so that volcanic hazards can be properly evaluated. Big, violent eruptions can send so much material into the atmosphere that it will change the color of sunsets or cool the global temperature by a few degrees. This happened in the 1880s when Krakatoa erupted in Indonesia. The sunsets were intensely red for a year and England did not have a summer for two years.

EARTHQUAKES

An earthquake is the result of the sudden release of energy that has been accumulating between two parts of the Earth divided by a fracture we know as a **fault**. The energy accumulates because the two sides of the fault cannot slide past each other easily; rather, they find a lot of resistance to sliding and this resistance locks the fault. When the resistance is higher than the blocks can stand, the fault snaps and an earthquake occurs.

Earthquake magnitude is measured by the Richter scale, which is a measure of the energy released by the earthquake. What we feel is measured by a subjective scale of intensity called the Mercalli scale. Earthquakes occur at all three plate boundaries because they all divide blocks of the Earth, where there is resistance to sliding.

Earthquakes occur below the surface of the earth but are located by latitude and longitude measurements. Such measurements, which act like a grid around the entire surface of the Earth, are used to define an earthquake **epicenter**. The depth of the earthquake is called a **focus** or **hypocenter**. Earthquakes are classified by their depths into shallow (0–70 km), intermediate (70–300 km) and deep (300–700 km). Big, shallow earthquakes like those on the San Andreas fault are highly destructive.

DIVERGENT MARGINS

In the 1950s it was discovered that in the middle of the oceans there were very long mountain chains emitting volcanic material. These chains, known as Mid-Ocean Ridges, are where new oceanic floor (basalt) is constantly being created. The material builds up symmetrically on both sides of the ridge with a deep central valley. There are volcanos and shallow earthquakes there. This type of boundary is called a **constructive boundary** because sea-floor material is generated here. Figure 5 illustrates these features.

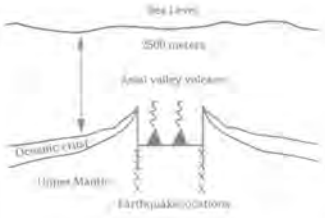


Figure 5 Divergent Plate Margin

Mid-ocean ridges can be followed for a continuous 40,000 km from the Atlantic to the Pacific, the Indian Ocean and so on.

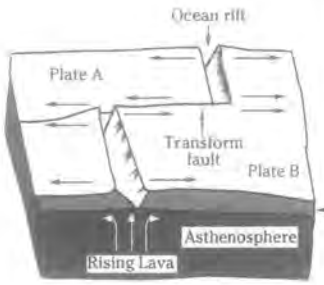


Figure 6 Transform Margin

TRANSFORM MARGINS

The ridges are offset by faults known as transform faults. These faults are plate boundaries that join ridges to ridges, ridges to trenches, faults to trenches, and so on. Material is not created nor destroyed at transform faults. They are vertical faults that generate shallow earthquakes. The best example is the San Andreas fault. This type of margin is illustrated in Figure 6.

CONVERGENT MARGINS

If material is created at the ridges and the Earth is not getting bigger, ocean crust must be destroyed somewhere. This occurs at convergent margins, also known as **subduction zones**. Here an oceanic plate dives into the mantle under another younger and lighter oceanic plate or continental plate, such as with the Pacific oceanic plate under the continental South America. A continental plate cannot subduct, so when two continents converge they crash together in what is known as a continental collision, generating large mountain chains, such as the Himalayas.

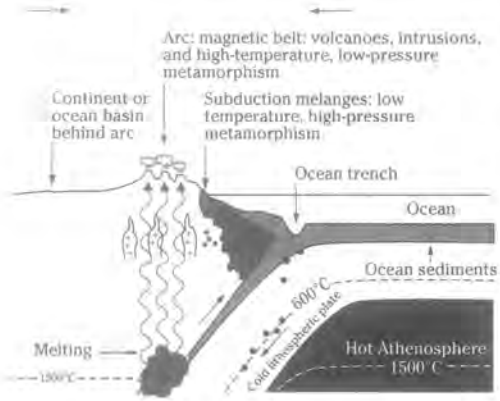


Figure 7 Convergent Margin

Subduction of an oceanic plate generates magma, which rises under the overriding plate and builds a volcanic line such as what takes place in the Andes. Subduction generates 99% of the seismic energy released every year, in shallow, intermediate, and deep earthquakes. It also generates the biggest earthquakes (9.5 on the Richter scale in Chile, 1960; 9.0 in Alaska, 1964). Convergent margins are illustrated in Figure 7.

CLIMATE

The study of atmospheric and hydrospheric systems (air and oceans) explains the climate of the planet. The greenhouse effect and other present-day environmental problems are related to climate. Climate is part of the external heat engine and is driven by the radiational energy of the Sun.

ATMOSPHERE

The composition of our atmosphere is shown in Table 1. It is composed of 78% nitrogen gas (N_2), 21% oxygen (O_2), about .93% argon (A), and minor amounts of carbon dioxide (CO_2). There are also traces of nitrous oxide (NO_2), methane (CH_4) and sulfur dioxide (SO_2).

The atmosphere did not always have this composition—free oxygen was not available until the first photosynthetic organisms appeared. This will be covered later in the chapter on "Life."

The atmosphere is divided into four layers: **troposphere**, **stratosphere**, **mesosphere** and **thermosphere**. The four layers are mentioned in ascending order from the bottom to the top of the atmospheric column in Figure 8.

Figure 8 also shows the temperature gradient in the atmosphere, as well as the position of the ozone layer. Ozone (O_3) is a compound of oxygen that absorbs and repels a large percentage of the ultraviolet radiation in solar energy.

The ozone layer protects us from the deadly UV rays of the Sun's radiation. Our use of chlorofluorocarbons enlarges the hole in the ozone layer, which reduces this protection.

GAS	CHEMICAL SYMBOL	CONTENT (% by volume)
Nitrogen	N_2	78.09
Oxygen	O_2	20.95
Argon	A	0.93
Carbon dioxide	CO_2	0.03
Total		100.00

Table 1 Principal Components of Dry Air

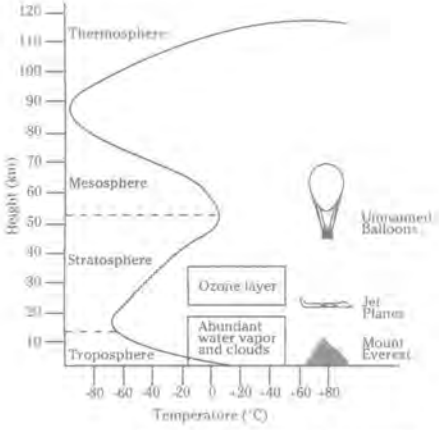


Figure 8 Structure and Temperature of the Atmosphere

OCEANS

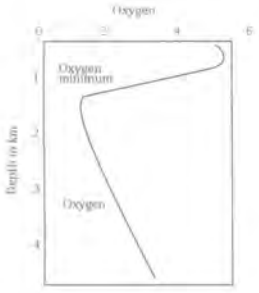


Figure 9 Oxygen Content of the Oceans

Not just composed of water, oceans have many other elements in solution such as sodium, potassium, and calcium, and gases such as carbon dioxide (see Table 2). All of the dissolved elements are critical for the survival of marine plants and animals.

Life in the deep oceans is limited greatly by the availability of food and light. The zone of the ocean that is well-lighted is called the **euphotic zone** (upper 200 meters) and the darker, deeper layers are called the **aphotic zone**. The amount of oxygen available in the oceans also decreases sharply at deeper levels, as shown in Figure 9.

The structure of the oceans detailed in the figure below shows that water temperature decreases to 4° C at a depth of 2000 meters in tropical and temperate regions. The temperature and salinity gradients in the oceanic column are shown in Figure 10.

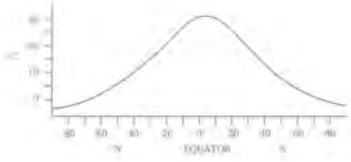


Figure 10A Surface Temperature of the Oceans

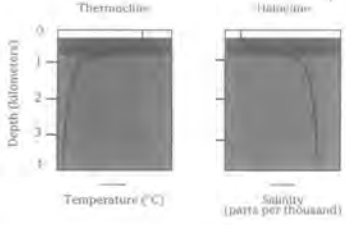


Figure 10B Temperature and Salinity of the Oceans with Depth

ELEMENT	AMOUNT IN OCEAN (G)	RESIDENCE IN TIME (YR)
Sodium	147×10^{20}	260,000,000
Magnesium	18×10^{20}	12,000,000
Potassium	5.3×10^{20}	11,000,000
Calcium	5.6×10^{20}	1,000,000
Silicon	5.2×10^{18}	8,000
Manganese	1.4×10^{15}	700
Iron	1.4×10^{16}	140
Aluminum	1.4×10^{16}	100

Table 2 Residence Time of Some Elements in Seawater

SOLAR HEATING —INSOLATION

The energy to carry out processes on the surface of the Earth comes from the Sun. Solar radiation, also known as **insolation**, is what spurs life and geological processes on the Earth.

Since the birth of the Solar System, the Sun has been radiating heat at a constantly increasing rate. This is the natural consequence of the growth of a star. The life span of a star like the Sun is about 1400 billion years, which means that the Sun will last for approximately another 10 billion years. The solar radiation will increase with time and cause the surface temperature of the Earth to get higher and higher until the Sun dies. When this finally happens, life on the Earth will probably die unless forms of life not dependent on photosynthesis evolve.

Climate is highly dependent on solar output variations. Seasons (winter and summer) and climatic zones are dependent on solar output. Figure 11 shows the angle of the Earth to the solar rays with different seasons and at different latitudinal zones. Variations in solar output do not follow just the seasonal cycle of summer and winter. They also follow other longer cycles that are directly related to long-period changes in temperature on the Earth, such as during glaciations.

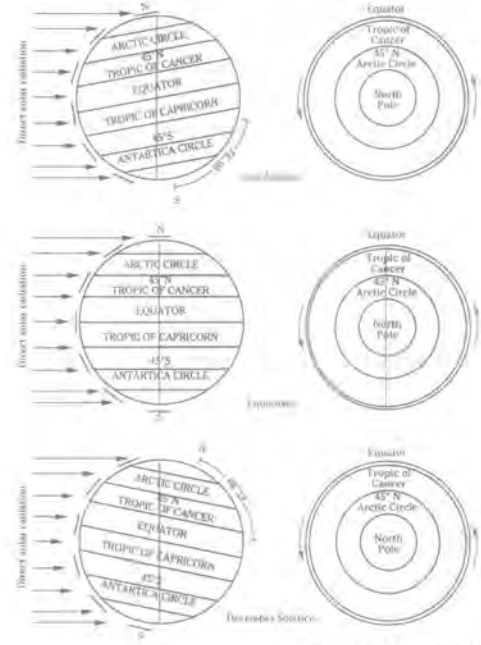


Figure 11 Exposure of the Earth to the Sun's Radiation

GLACIATIONS AND CHANGES IN THE ORBIT OF THE EARTH

Scientists have argued for a long time on the cause of the recent (10,000 to 15,000 years ago) ice ages since they were discovered by Louis Agassiz in the 1800s.

In the 1930s, a mathematically sound hypothesis for glaciation and long-period climate changes was proposed by Milutin Milankovitch, a Yugoslavian astronomer. He proposed the astronomical theory of climate, which says that variations in the Earth's orbit influence climate by changing the seasonal and latitudinal distribution of incoming solar radiation.

Incoming solar radiation falls at different angles in different seasons. The angle of incidence depends on the tilt of the rotation axis of the Earth (**axial tilt**). This tilt is technically called **obliquity**, and is measured with respect to a plane that crosses the Sun and contains the orbit of the Earth (plane of the ecliptic).

Another factor that influences the angle of incidence of solar radiation is the **precession**, or the measure of how the equinoxes succeed each other and how this affects the seasonal configuration of the Earth. Precession depends on the longitude of the perihelion (the point at which the Earth is closer to the Sun).

A final factor that influences the angle of incidence of solar radiation is **eccentricity**, which is a measure of how much the orbit of the Earth around the Sun differs from a perfect circle.

Obliquity, eccentricity and precession of the equinoxes are called the **orbital parameters**, and variations in them determine changes in the solar heating and therefore affect our climate. These parameters cause changes with different period lengths:

Eccentricity	Long-period cycles	95,000; 136,000; 413,000 years
Obliquity	Medium-period cycles	41,000 years
Precession	Short-period cycles	19,000; 23,000 years

Changes in climate are classified according to the lengths of their cycles:

Tectonic band	More than 400,000 years
Milankovitch band	10,000 to 400,000 years
Millenium band	400 to 10,000 years
Decadal band	10 to 400 years
Interannual band	2.5 to 10 years
Annual band	0.5 to 2.5 years

Changes in the tectonic band are attributed to tectonic effects such as mountain building. This is a current topic of research in paleoclimatology and is known as **Tectoclimatology**.

Changes in the Milankovitch band are due to changes in the orbital parameters mentioned above. These changes are the direct result of the gravitational pull of the giant planets (Jupiter and Saturn) on the Earth.

Changes in the millenium band are attributed to episodes of flux of volcanic gases, and expansion and contraction of alpine glaciers. Changes in the millenium band are due to episodes of explosive volcanism.

Finally, changes in the annual and interannual band are attributed to the well-known seasonal fluctuations of solar radiation. These are probably due to

motions of the Earth around its own orbit (wobbling of the axis of rotation, for example) and not the geometry of the orbit as in the orbital parameters.

A variation in the solar output that frequently occurs is related to sunspot cycles. A sunspot is a dark area of the sun's surface, which represents a region of lower temperature than the rest of the sun's surface. Sunspot cycles are fluctuations in the ultraviolet radiation from the Sun. The approximate duration of a cycle is 11 years. The influence of sunspot cycles on the climate is still a controversial and constantly debated topic.

EARTH'S RESPONSE TO SOLAR HEATING

The Earth does not just passively absorb the radiation from the Sun, but returns some of the radiation back to space. It does not emit it back at the same frequency, but at a lower one. Emissions from the Earth are in the infrared spectrum while radiation from the Sun comes from the whole spectrum of light, from UV (ultraviolet) rays to visible to IR (infrared). The light spectrum is shown in Figure 12.

Part of the solar radiation (UV rays) is absorbed by the ozone layer, part is reflected by clouds and solids, part is absorbed by water vapor, dust particles and clouds, and 47% is absorbed by the ground. This is shown in Figure 13.

The overall albedo is the most important process preventing the Sun from frying us. It is measured by the amount of the Sun's radiant energy that is reflecting off clouds, water and land surfaces. This reflectivity is called **albedo**. Table 3 shows the albedo of several solid and fluid materials.

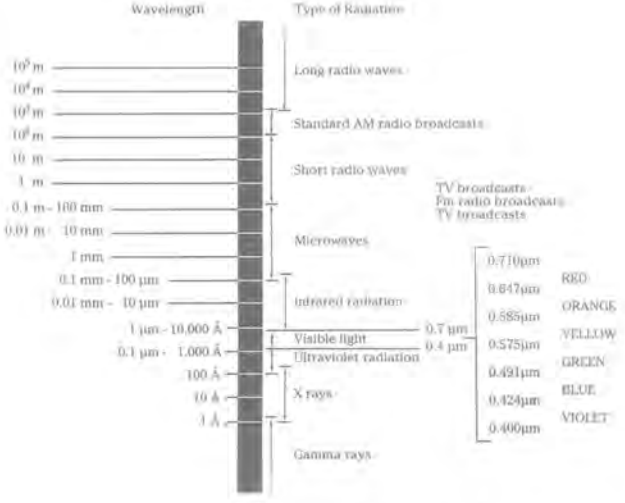


Figure 12 The Electromagnetic Spectrum

ALBEDO EFFECTS

SURFACE	%
Fresh snow, high sun	80-85
Fresh snow, low sun	90-95
Old snow	50-60
Sand	20-30
Grass	20-25
Dry earth	15-25
Wet earth	10
Forest	5-10
Water (sun near horizon)	50-80
Water (sun near zenith)	3-5
Thick cloud	70-80
Thin cloud	25-50
Planetary albedo	30
Ice	50-70
Fields dry	20-25
Fields green	3-15

Table 3 Albedo of Various Surfaces

Albedo is the ratio of light reflected to light received. The combination of the following mechanisms gives the total albedo of Earth and atmosphere.

Orbiting satellites keep track of the albedo in order to monitor the rate at which the earth's surface is heating when exposed to the sun. Such instruments measure short-wave and infrared radiation, both coming in from the sun and going out from the atmosphere and the earth's surface below. The earth's average albedo has been estimated at between 29% and 34%.

There are four major mechanisms for returning radiation to space:

- Reflection from dust, salt, ash and smoke particles in the air;
- Reflection from clouds;
- Reflection from the ground; and
- Refraction by air molecules.

If a ray reaches the Earth after all these obstacles then it still has to deal with the Earth's albedo. This varies depending on the composition of the surface. The average surface albedo is only 4% but in certain areas, for example the poles, the albedo is between 50–70%. Some of these values are tabulated in Table 3.

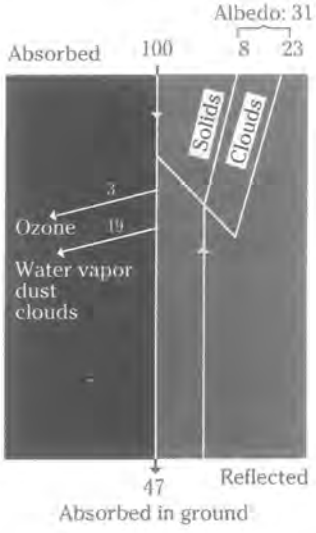


Figure 13 Solar Energy Budget

Because of its high albedo, the amount of snow that falls in a year will affect the climate and the average temperature of the Earth. The presence of more deserts will have the same effect. Deforestation, even though its albedo is very low, also affects the weather because more dry uncovered land with a high albedo gets exposed. The Earth retains this heat and transports it from equatorial latitudes to polar latitudes.

HEAT TRANSPORT & ATMOSPHERE-OCEAN INTERACTIONS

The heat absorbed by the ground and by the ocean surface waters is greater at the equator than at the poles because of the higher amount of insolation at these regions. This heat is transported from the equator to the poles both by the atmosphere and by the oceans. In a general sense, the atmosphere does it using winds and convection cells (like the mantle in the internal heat engine), and the oceans using currents, both surface and deep.

ATMOSPHERIC TRANSPORT

Atmospheric transport, or global circulation, takes place largely due to winds. The pattern of global circulation is characterized by permanent anticyclones and cyclones, called centers of action, and by persistent wind systems.

At low latitudes near the Earth's surface, the easterly trade winds dominate. At high latitudes and aloft, the prevailing westerlies dominate. The occurrence of zonal winds is explained by the deflection of motions of the meridians due to the rotation of the Earth. This is the **Coriolis effect**, which also says that particles in the Northern hemisphere tend to go to the right and in the Southern hemisphere to the left. The driving force for this circulation is the variation in solar radiation with latitude.

Near the surface of the Earth the pressure is low at the equator and high at the poles. This gives rise to a circulation along the meridians, with the heated air rising near the equator and flowing high towards the pole and the cooled air descending at high latitudes and flowing towards the equator at the ground. The stream of air moving towards the pole is deflected to the east by the Coriolis force, originating westerly winds, and the one flowing towards the equator at the ground will be deflected to generate the easterlies. Friction with the surface of the Earth does not allow the pressure and Coriolis force to balance so that the circulation is not just zonal but also along the meridians.

The pattern of meridional circulation was discovered by George Hadley in the 1700s and the circulation patterns along the meridians are called Hadley cells. Since friction does not allow pressure and Coriolis force to balance, the pressure force is greater at great heights than the Coriolis force and the air at great heights is pushed towards the poles. At high latitude the air tends to cool and descend, completing the meridional Hadley cell shown in Figure 14.

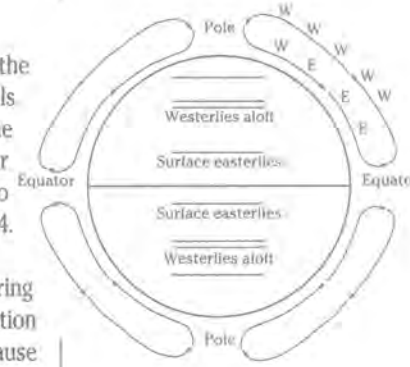


Figure 14 Hadley Cells

The Hadley cells, one in each hemisphere, perform the function of transferring excess heat from the Sun at low latitudes to higher latitudes. The true circulation pattern is not as simple as just having a Hadley cell in each hemisphere because of a law of physics called conservation of angular momentum. The results of applying the law show that Hadley cells alone will cause very high-speed winds, which in turn will cause great instability in the global circulation pattern. Friction between the Earth and the atmosphere also complicates simple Hadley cells.

Heat is also transported by waves and vortices. Waves in the atmosphere are the result of the breakdown of the zonal flow due to high-speed winds and lateral

mixing of the air. Swirls or vortices and cyclones and anticyclones also result from the breakdown of the zonal flow. These are very effective at transporting the heat in the North-South direction.

OCEANIC TRANSPORT

Heat transport from solar radiation is also accomplished via oceanic circulation. Circulation of the oceans is one of the main factors in the total heat budget of the Earth.

Oceans act as a great reservoir of heat for the planet. The Sun's energy heats up the surface of the ocean, which stores the heat and transports it via oceanic currents both at the surface and at depth. Like the atmosphere, the ocean currents move heat from low latitude to high latitudes.

HEAT STORAGE

The oceans are very large reservoirs of water that can hold a lot of heat without changing their average surface temperature by very much. This is known as the **climatic flywheel**.

Oceans are better at holding heat than the ground or the air, and absorb more heat per unit area at the equators than at the poles. The heat is transferred to the colder areas by convection. This moderating effect on the climate is easily observed in temperate coastal regions where warm air from the seas is transferred to the land.

SURFACE CURRENTS

The wind-driven circulation of the oceans is strong, but extends only within the upper 1000 meters of the ocean. The wind system described in the previous sections exerts a stress on the surface of the ocean, generating surface currents. The easterly trade winds form the equatorial currents of all oceans.

When intersected by land these currents are deflected North and South, as in the Atlantic and Pacific oceans. Deflected currents travel along the western parts of the oceans and are called western boundary currents—they are the strongest in all the oceans. One is the Gulf Stream.

These currents are driven by the westerly winds across the ocean and form currents that flow back into the equatorial region, completing the convection cell, similar to what occurs in atmospheric circulation. These cells or **gyres** occur in subtropical regions in the N and S Pacific, N and S Atlantic and S Indian oceans. The N and S gyres are separated by a countercurrent that flows east.

In the N Indian Ocean a similar gyre is found, but this changes direction every six months due to reversals in atmospheric circulation called **monsoons**. Some weaker gyres are found in northern subpolar regions. In southern gyres the flow is not blocked by land, so the Antarctic circumpolar flows completely around the world. The circulation is driven by differences in pressures between high and low areas of the sea surface.

The action of the wind on the surface of the ocean also causes vertical motion. These vertical currents are called upwellings and occur when prevailing winds blow parallel to a coast. These upwellings are in offshore and subsurface waters, which frequently are rich in nutrients. When this is the case, an area of high biological productivity may develop.

DEEP CURRENTS

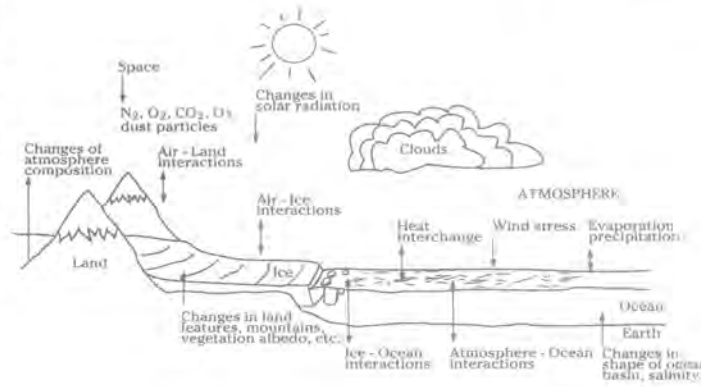
Variations in water density cause deep water circulation known as **thermohaline circulation**. These density differences develop at the air-sea interface and are the result of differences in the amount of heat received and the effects of dilution and evaporation. The dense, cold waters of high latitudes sink and slowly flow towards the equator. This is a convective process, like that of the mantle inside the Earth. This process occurs principally in two places, the North Atlantic and the Antarctic.

The North Atlantic Deep Water is very clearly defined by its temperature, oxygen content and salinity. The Antarctic Bottom Water travels north along the ocean floor across the equator. The bottom water path is influenced by the topography of the ocean floor.

ATMOSPHERE-OCEAN INTERACTION

The interaction between ocean and atmosphere is shown in Figure 15, the hydrologic cycle. This cycle can be summarized as follows: the wind blowing over surface waters generates waves, mixes the surface waters and removes water vapor from the sea surface. The water vapor is taken into the atmosphere by evaporation and transferred to land by precipitation, which returns it to the rivers and groundwater that eventually return it to the sea.

Figure 15 Ocean-Atmosphere Interactions



GREENHOUSE EFFECT AND CLOUD COVER AND THEIR INFLUENCE ON CLIMATE

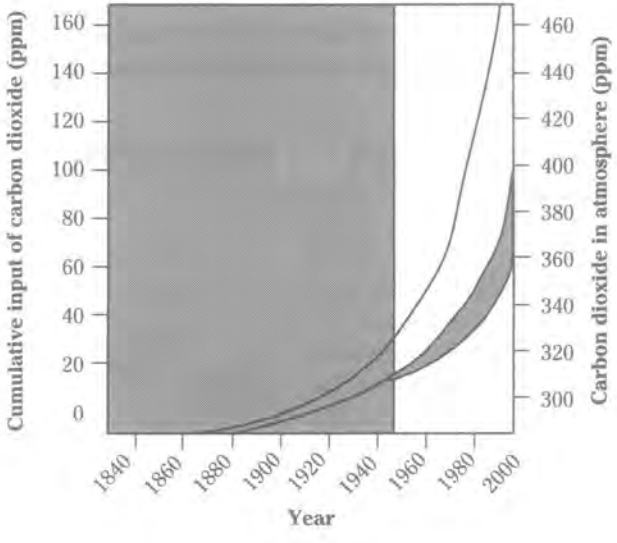
GREENHOUSE EFFECT

In recent years we have heard a lot about global warming and the greenhouse effect due to increasing consumption of fossil fuels and continuous deforestation, but few accurately know what the greenhouse effect is and how to gauge its delicate balance on the Earth. Not even the experts can predict the Earth's behavior in terms of global warming trends, because we don't know enough about climatic fluctuations and CO_2 levels in the past.

The greenhouse effect can be described as follows:

The atmosphere of the Earth is fairly transparent to the incoming visible rays of the Sun, but 48% of the radiation is absorbed by the ground and emitted back as infrared radiation. The atmosphere is opaque to infrared because carbon dioxide and water vapor absorb the radiation instead of allowing it to go back into space. This absorbed radiation heats the atmosphere, which radiates heat back to the Earth. Without this effect the Earth's surface temperature would be below freezing and the oceans a mass of ice.

Figure 16 CO_2 Levels in the Past



Any process that alters the delicate balance of CO_2 and water vapor molecules may affect Earth's climate. Burning fossil fuels increases the amount of CO_2 in the atmosphere, and deforestation of the Amazons prevents plants from taking CO_2 and returning oxygen to the atmosphere.

Since the beginning of the Industrial Revolution the amount of CO_2 in the atmosphere has increased steadily to values that we think have never been reached before (Figure 16 shows the increase since 1840 and predictions for the future). Some of these CO_2 molecules are taken from the atmosphere and dissolved in the oceans, because nature tries to reestablish equilibrium, but we are releasing so much CO_2 that the planet cannot rebalance itself.

Increases in global temperature caused by the greenhouse effect may also increase sea levels by 70 meters or more by melting part of the Antarctic ice sheet. This could be devastating to many coastal cities.

CLOUD COVER

We have already discussed briefly the effect of cloud cover on albedo and therefore on insolation. Cloud cover also affects the reflection of incoming rays from the Sun. Clouds form as the result of the condensation of rising hot air into the lower part of the atmosphere. Clear air descends to the ground where it is heated, then rises as it warms up; it goes up into the atmosphere where it cools and condensates, trapping a lot of water vapor, which in turn reflects the sunlight, making it less intense.

Global warming would evaporate more water and therefore more water vapor will go into the atmosphere and be trapped into clouds which will in turn cover more of the sky and decrease the intensity of sunlight that comes in. This could balance warming, but water vapor also traps infrared radiation.

SimEarth

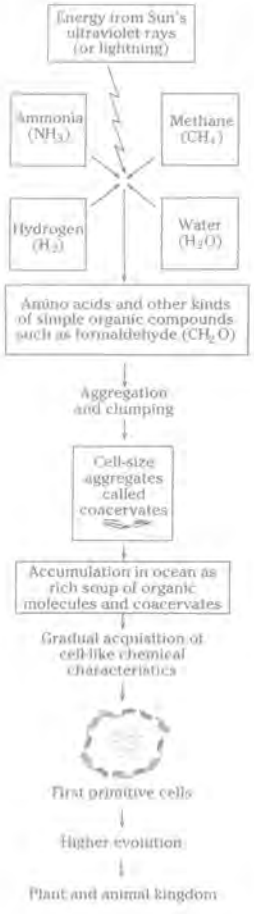
LIFE

Why does life flourish on the Earth and not on any other planet? In this section we will take a look at the history of planetary evolution from the origin of life up to vertebrates and humans.

ORIGIN OF LIFE

In the early 1920s a young Russian biochemist, Aleksandr (Ivanovitch) Oparin, theorized that there must have been a beginning of life at a certain point in Earth's history and that we could make intelligent guesses as to when it was and how it occurred.

Figure 17 Origin of Life


Energy from Sun's ultraviolet rays (or lightning)
Ammonia (NH_3)
Methane (CH_4)
Hydrogen (H_2)
Water (H_2O)
Amino acids and other kinds of simple organic compounds such as formaldehyde (CH_2O)
Aggregation and clumping
Cell-size aggregates called coacervates
Accumulation in ocean as rich soup of organic molecules and coacervates
Gradual acquisition of cell-like chemical characteristics
First primitive cells
Higher evolution
Plant and animal kingdom

Oparin theorized that the atmosphere of the early Earth lacked oxygen but contained gases such as ammonia, methane and hydrogen. In that kind of atmosphere (without ozone), UV rays would have energized the components and generated the first synthetic reactions of organic compounds such as amino acids, the building block of life. These in turn would clump together in long chains and possibly take on the characteristics of the primitive cell. He called this early amalgamation of compounds **primordial soup**. Figure 17 diagrams this process.

In the 1950s Stanley Miller devised an experiment that demonstrated how it may have happened. He built an apparatus that zapped a primordial soup with electrical jolts comparable to lightning, and produced amino acids. The step from amino acids to actual life and genetic coding is not yet understood. Other theories suggest that the early atmosphere was primarily carbon dioxide, water vapor and nitrogen, as expected from degassing of the Earth. In this environment, amino acids have also been produced.

Others propose that building blocks may have originated in nearby comets and come to Earth on impacts. The origin of the nucleic acids DNA and RNA that enable life to replicate and transmit genetic information to the offspring is not clear, but it is obvious that this was the final and most crucial step towards organized life.

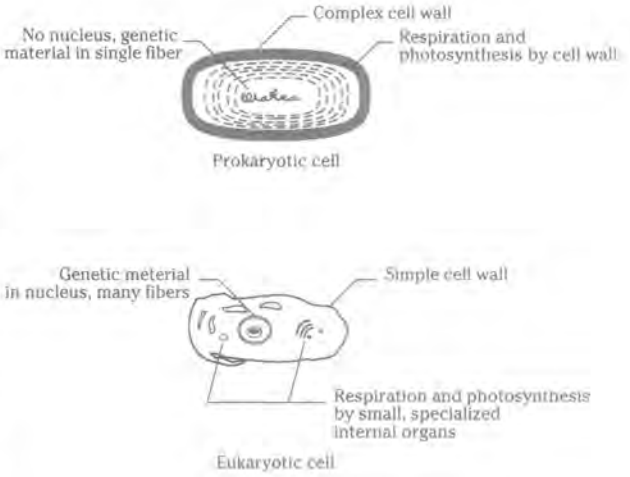
If you ever watch the old "Star Trek" series, you may have seen a couple of episodes in which they discuss the possibility of life based on silicon instead of carbon (Si and C are of the same chemical group and possess many of the same characteristics). Silicon-based life is highly unlikely because one of the most outstanding properties of carbon is that it is gaseous at room temperature rather than solid like silicon. This property enabled carbon to make organic compounds in the fluid state, at low temperatures, with lower energy requirements than that of silicon. Silicon is too heavy and too inert to react at the temperatures at which life as we know it survives.

EARLY ORGANISMS

The first known organisms on Earth are some carbonaceous remains of primitive cells with no nucleus that date back 3.5 billion years. **Prokaryotes**, which still exist today in bacteria, algae, ameba, and other simple organisms, lack a nucleus, the central part that contains all the genetic material, as well as specialized organelles for other cellular activities. These first organisms were probably **anaerobic** and fed on methane.

Two billion years ago, organized life—like algae—were thriving on the planet. One billion years ago the **eukaryotic** cell, the cell with a nucleus, developed. One of the most popular theories on the origin of eukaryotes is that two prokaryotic cells may have stayed together after mitosis (cell division) or they may have started a symbiotic relationship. One may have captured the other and from there the "trapped one" would have developed into a nucleus, and also into several different organelles that perform different activities, such as breathing, metabolizing, etc. inside the cell. This is seen in modern eukaryotes in that **mitochondria** (the organelles that breathe for us) have their own genetic material and replicate separately from the rest of the genetic material in the cell. Figure 18 shows the difference between eukaryotes and prokaryotes.

Figure 18 Cell Types


Complex cell wall
No nucleus, genetic material in single fiber
Respiration and photosynthesis by cell wall
Prokaryotic cell
Genetic meterial in nucleus, many fibers
Simple cell wall
Respiration and photosynthesis by small, specialized internal organs
Eukaryotic cell

Shortly after the evolution of eukaryotic cells (in geologic time), the first multicellular organisms or **metazoans** evolved. With the advent of metazoans a very diverse range of life-forms evolved, including the development of soft-bodied organisms as seen in the Ediacara fauna of Australia and the Burgess shale in Canada.

Six hundred million years ago, after the explosion of diversity of soft-bodied organisms, the first shelled organisms developed in a period called the **Cambrian**.

The rate of evolution between one billion years ago and 600 million was so much higher than at earlier times that it could be termed explosive. From a world dominated by algae and bacteria we passed to a world full of different species that in some form or other still survive today. There were more species alive at that time than have evolved since.

The geologic time scales and the different life-forms at each period are shown in Table 4.

ERA	PERIOD	EVENTS	BEGAN MILLIONS OF YEARS AGO
CENOZOIC	Quateranary	Age of humans. Four major glacial advances.	2
	Tertiary	Increase in mammals. Appearance of primates. Mountain building in Europe and Asia.	65
MESOZOIC	Cretaceous	Extinction of dinosaurs. Increase in flowering plants and reptiles.	140
	Jurassic	Birds. Mammals. Dominance of dinosaurs. Mountain building in western North America.	195
	Triassic	Beginning of dinosaurs and primitive mammals.	230
PALEOZOIC	Permian	Reptiles spread and develop. Evaporate deposits. Glaciation in Southern Hemisphere.	280
	Carboniferous	Abundant amphibians. Reptiles appear.	345
	Devonian	Age of fishes. First amphibians. First abundant forests on land.	395
	Silurian	First land plants. Mountain building in Europe.	435
	Ordovician	First fishes and vertebrates.	500
	Cambrian	Age of marine invertebrates.	600
PRECAMBRIAN TIME		Beginning of life, at least five times longer than all geologic time following.	

Table 4

EVOLUTION OF OXYGEN-RICH ATMOSPHERE AND PHOTOSYNTHESIS

We have already stated that primitive life evolved in an anaerobic atmosphere with little or no oxygen. Obviously, many changes have occurred since. Even the Cambrian organisms needed oxygen to survive.

Around three billion years ago (with the advent of blue-green algae) organisms must have developed the ability to photosynthesize—take CO_2 from the atmosphere and with the aid of the sun's radiation, break it down and use the carbon to make the food, complex carbohydrates and other energy compounds that enabled the organism to survive. In return the organisms give free oxygen back to the atmosphere.

The oxygen must have started to accumulate in the atmosphere, and soon its levels would become high because few organisms were able to breathe and deplete it. The accumulation of oxygen was poisonous to many organisms, which must have died out as a consequence.

Some time just before 600 million years ago the amount of oxygen reached high enough levels to allow rapid evolution of the invertebrates in the Paleozoic period. For the rest of the life of the planet the amount of oxygen has been kept constant by photosynthetic organisms.

Life not only changed the atmosphere, but also changed the geology, by originating new types of sediments, rocks and geographical features such as coral reefs.

HISTORY AND DIVERSITY OF LIFE

Diversification of life had already taken place before the Cambrian explosion. That diversification is hard to describe because of a lack of fossil evidence, so we will concentrate on life from the Cambrian period on.

CAMBRIAN PERIOD— INVASION OF THE SEAS

The Cambrian initiation was the beginning of organisms with hard body parts or shells. This provided defense against predators and also prompted better fossil preservation. The most common hard body parts were made of calcite, chitin and SiO_2. The fossil record really begins at the beginning of the Cambrian era because of the better preservation of hard body parts.

The first fossils with hard skeletal parts were the **trilobites,** an extinct group of **arthropods** related to crabs, lobsters and shrimps. These first trilobites had large eyes, long antennae, and a well-developed nervous system. In the early Cambrian over 90% of all the fossils specimens were trilobites. Other common animals were the **brachiopods**, similar to clams, and some **echinoderms** (starfishes and sand dollars). Many other organisms became extinct and left no descendants. All these animals were marine and invaded the seas all around the world. Other marine organisms such as corals, mollusks, fish, etc., developed during the rest of the Paleozoic and also into the Mesozoic and Cenozoic.

INVASION OF LAND: PLANTS AND ANIMALS

The most outstanding achievement of the post-Cambrian Paleozoic was the invasion of land by the first plants and animals. This opened a lot of new **niches** (ecological habitats) for animals to evolve.

Organisms that lived underwater had gills or special systems to breathe, and in order to survive on land they needed to develop a vascular system that enabled them to use oxygen or carbon dioxide that was not dissolved in water. Plants did it first in the early Devonian period.

Transition from water to land took place in the Devonian and the mid-to-late Paleozoic periods. One of the reasons why it did not take place earlier is that there were extensive shallow seas over the land, so there was not very much dry land available.

Unfortunately the fossil record on land is not as good as the marine record because preservation is a lot worse on land. The record is spotty, discontinuous and full of gaps even in younger rocks.

PLANTS DO IT FIRST

In the mid-to-late Paleozoic plants developed a vascular system that allowed them to survive without being underwater. This system consisted of very narrow, elongated hollow cells through which water and food could circulate. It was also a way to maintain the needed water balance inside their bodies. They also needed to develop a rooting system (land plants need to be attached), and a support for the body like cellulose or lignin. Once these adaptations were developed, the first land plant could survive far away from water and depend only on precipitation and groundwater.

Further into the Paleozoic era, larger and more plants developed. The first land plants were small grass-like weeds or bushes. Later into the Carboniferous period, large ferns took over, and shortly after that came the conifers, which dominated most of the Mesozoic era. It was not until the end of the Mesozoic and the beginning of the Cenozoic that flowering plants, with their efficient reproductive system, came along.

LAND ANIMALS AND THE EVOLUTION TO HUMANS

In this section we will concentrate on the evolution of vertebrates after they reached the land, all the way to humans. We have not included a discussion on the mechanisms of evolution itself, although they will be mentioned in relation to theories of mass extinctions. We leave it to the reader to consult more specialized books on the subject.

The oldest known land animals including freshwater organisms were invertebrates or arthropods. A land scorpion and a millipede were found in early Devonian rocks. Insect-like fossils of this age have also been found. Snails and slugs do not appear until the late Paleozoic, after the tetrapods or four-legged vertebrates.

Apart from a few anomalous organisms, vertebrates evolved straight into fishes and from there into amphibians, reptiles, mammals and birds. Fishes will not be discussed except for their link to the invasion of land. Freshwater Devonian fishes, crossopterygians, had both lungs and gills for breathing, so they developed the most important adaptation for living on land: being able to breathe air and not water. They also had thick fleshy fins, which enabled them to walk. The fins gradually changed to short stubby legs. The bone structure of these fishes matches those of the early amphibians.

These adaptations, which undoubtedly were meant at first only to help them survive as successful freshwater fishes, then became useful to transfer completely to land. They were probably forced to transfer to land by changes in climate in the Devonian that dried up freshwater niches. There must have also been more food available on land as freshwater areas dried out.

After these fishes, the first real land animals in the fossil record are amphibians, the ancestors to toads and frogs. These animals lived on land near the water since they often had to go into the water to breathe and breed. As evolution proceeded the amphibians became better adapted to living on land by developing stronger limbs.

From one of the amphibian lineages the first reptiles evolved. Reptiles started appearing in the Carboniferous period and began dominating the environment up until the end of the Mesozoic era. The reptiles had a big advantage over the amphibians—they didn't need to go to the water to breed. Reptiles developed the amniotic egg, an egg with a hard, porous shell, which allowed the egg to survive without the constant presence of water for breathing. Unlike the amphibians, the reptile youngsters developed right from the egg without a larval or tadpole stage.

Several types of reptile lineages developed in the Paleozoic, but the two most important and interesting to us are the **Synapsida**, or mammal-like reptiles, from which mammals developed in the Mesozoic, and the **Diapsida**, or ruling reptiles, which included the dinosaurs. The end of the Paleozoic saw the development of many species of reptiles, especially the dinosaurs, which also proliferated, maybe even more, throughout the Mesozoic. There were many kinds of dinosaurs: herbivores, carnivores, flying, aquatic, etc.

Mammal-like reptiles developed in the Triassic (the beginning of the Mesozoic). These reptiles had longer and stronger limbs than the other reptiles and their brain cases became progressively larger. Their dental structure approached that of modern mammals.

The ruling reptiles had one important group, the **thecodonts**, which then became the dinosaurs. These animals were bipedal and had tiny skulls. The front limbs were not used for walking but for handling food. Two main groups of dinosaurs became important: those with a pelvic bone similar to other reptiles (saurischians) and those with a pelvic girdle similar to birds (ornitischians). Saurischians were small and from them developed the large predators of the late Mesozoic such as Tyrannosaurus rex. Most dinosaurs nonetheless were herbivores, not carnivores.

From dinosaurs developed the first bird-like reptiles, and from them, birds. A very famous bird-like reptile is Archaeopteryx, which had feathers and a wing structure very similar to modern-day birds.

As mentioned before, mammals evolved from the Synapsida, the mammal-like reptiles. The first mammals were small, with small brain capacity; most of them were probably rodents (mice, etc.). Mammals were not very common in the Mesozoic, except for rodents and monotremes (duck-bill platypus). Not until after the demise of the dinosaurs at the end of the Cretaceous did they start taking over the land, especially with the evolution of **placental** and **marsupial** mammals.

Marsupials (kangaroos and opossums, for example) are animals that give birth to young incapable of fending for themselves; the mother keeps them in a pouch outside her body until they are fit for life on their own. Many types of marsupials are only found in Australia and New Zealand. This is because early during their speciation the continents separated (the breakup of Pangaea), isolating Australia from the rest of the world.

Placentals give birth to completely developed offspring that feed from the milk produced by the mother's mammary glands. After a short period of milking they are ready to start life on their own.

Mammals are very familiar to us: rodents, canines and felines (dogs and cats), ruminants (cows), and others. Those most important in human evolution are the primates.

Primates originated in the Early Tertiary period, after the demise of the dinosaurs. They were omnivores rather than insectivores. They adapted to life in trees—one of their fundamental evolutionary steps was the development of a grasping hand with an opposable thumb. Another adaptation was the forward migration of the eyes, which provides stereoscopic or three-dimensional vision.

Primates known to us are the **simians** (monkeys) and **anthropoideans** (man-like).

Simians were preceded by prosimians, which gave rise to the true monkeys and apes of the simians. In the anthropoideans there are three groups: New World monkeys, Old World monkeys and Hominoids, which includes human beings and apes. The only one we will talk about in some detail is the Hominoids.

HOMINOIDS AND HUMAN EVOLUTION

The hominoids include the chimpanzee, the orangutan, the gorilla, the gibbon and human beings. It isn't until the Oligocene (~35–24 million years ago) that these groups start differentiating. Of all these groups, one genus dating back to the late Miocene (~5 million years ago) is apparently the direct ancestor to modern human beings. This is the so-called **Ramapithecus**. Homo sapiens developed in the Pleistocene about 4 million years ago during the glaciation epochs. The upright posture and ground-dwelling habits of human beings were already established in Ramapithecus. This is also true of other apes. Grasping hands are common to all primates and the use of tools is observed in chimpanzees. Language has been taught to chimpanzees and gorillas, although their vocal chords are different than ours. They can also teach it to their offspring as proven in some recent experiments.

What makes human beings strikingly different than the rest of the primates is their brain capacity—much larger with respect to their size than any other primate. The development of a complete, complex language is also a characteristic of human beings.

Human beings are the only animals that are capable of totally modifying their environment, for better or for worse. They are the only animal capable of creating new niches and modifying existing ones.

Another characteristic that distinguishes a human being from an animal is the ability to think of the long-term future. Human beings and animals share the memory of the past and the living in the present, but human beings are unique in predicting the future and also in questioning their existence.

The evolution of early human beings is shown in Figure 19. There are three principal stages in the evolution of early human beings: Australopithecus, Homo erectus, and Homo sapiens. The first stage is the one to which the famous Lucy, discovered by Donald Johannsen, belongs. The Australopithecines were similar to modern human beings, but although they used tools and weapons, they

Australopithecus afarensis (Lucy) - found only in Africa; walked before the development of a large brain (compared to ours).

Homo habilis - first tool maker.

Homo erectus - made acheilian (core) tools; migrated out of Africa.

Homo sapiens - made blade tools (flaking); also migrated out of Africa; development of agriculture, etc.

Figure 19 The Human Evolutionary Lineage

had very small brains. Homo erectus lived at the same time as the Australopithecines, and may have developed independently. The species was more advanced than the Australopithecines and had a higher brain capacity. They used stone tools, such as hand axes, made from flint. This species became widely distributed and is the direct ancestor of modern human beings.

Fossils of Homo erectus range in age from 700,000 to 200,000 years old. Homo sapiens is contemporaneous in age with Homo erectus, appearing for the first time 500,000 years ago. The first example of sapiens is Neanderthal Man, a large-boned race that lived 100,000 years ago. After sapiens originated, different historical ages developed, such as the Paleolithic and Neolithic.

FOOD CHAINS

A subject of great importance in a world with an ever-growing population is the availability of food. The food chain is an organizational scheme that describes which organisms feed on which, and which ones are essential for the survival of the others. It is like a pyramid because the organisms at the base are most abundant.

At the base of our food chain are organisms that produce their own food: photosynthetic organisms such as bacteria, plants, and plankton in the oceans. Upon these feed higher organisms, herbivores (plant-eaters) and omnivores (eating both animal and vegetable matter). If the plants were to die, all cows will die as a consequence—there would be no food left for them.

On top of herbivores at the peak of the food chain are carnivores (animal-eaters) and omnivores. Good examples are lions, tigers, cats, dogs and humans.

If we kill photosynthetic organisms by deforestation, polluting the oceans or by other environmental problems, we affect the base of the food chain and decrease the possibility of survival of the top of the chain—including ourselves.

MASS EXTINCTIONS

Mass extinctions are very important events that affect the rates at which evolution occurs. A mass extinction is defined as the death of 70% or more of the total biomass of the planet at any given time. Biomass is the total weight of all living matter on the planet. Mass extinctions have occurred at least five times in the geologic past within the **Phanerozoic** alone. Extinctions during and before the Cambrian are difficult to document.

The most massive extinction known occurred 225 million years ago at the Permian-Triassic boundary. Another one occurred at the next boundary, Tria-

ssic-Jurassic, about 190 million years ago. During the Cretaceous another important extinction occurred around 100 million years ago.

The second largest extinction was at the Cretaceous-Tertiary boundary, when all the dinosaurs became extinct. The mass extinction of the dinosaurs has become very famous partially due to the hypothesis that the cause of the extinction was an extraterrestrial object: a meteorite.

Mass extinctions are important because even though a large sector of the population was wiped out, niches were left available for newcomers that could adapt very fast and evolve rapidly into many new species. This seems to be the case after every extinction—a new group of living organisms takes over and evolves at a very high rate. During periods of time without mass extinctions, species also become extinct, but at a low rate, an event known as a **background extinction**. Evolution also takes place very slowly during such periods.

Are mass extinctions catastrophic or are they gradual events? The debate continues. It was generally believed that mass extinctions were a slow, gradual process like evolution but more and more evidence is being uncovered concerning the sudden disappearance of many unrelated species at the same time. This has been proven at the Cretaceous-Tertiary boundary, where within one centimeter of rock (which corresponds to a relatively short period of time) all evidence of Cretaceous fossils disappears and Tertiary fossils come into play. This kind of boundary impact layer can be seen in Gubbio, Italy.

NEMESIS AND THE IMPACT THEORY

We have mentioned the extinction 65 million years ago at the Cretaceous-Tertiary boundary of dinosaurs. Dinosaurs were not the only animals that died: **ammonites**, very important marine fossils, also went extinct, as well as many other land and marine animals and plants.

One of the marine groups that went extinct is the planktic forams (small, calcareous, floating unicellular organisms that lived in Cretaceous seas). These organisms are found in limestones in the Apennines of Italy. The last bed of the Cretaceous limestone has big planktic forams; the first bed of the Tertiary has one small planktic foram and nothing else. In between is a layer of clay about 3 cm thick known as the "boundary clay."

In 1980, Luis and Walter Alvarez from UC Berkeley took samples of that clay to measure the amount of an element called **iridium**, which is not very abundant on the Earth's surface but more abundant in extraterrestrial objects. Iridium rains at a constant rate, which made it very useful for measuring the amount of

time it took to deposit the layer of clay and therefore how long it took for the extinction to happen. When they measured the samples of boundary clay, they found that the levels were low in the limestone above and below the clay, but within the clay, iridium was at a high peak—at the same level as that in meteorites and comets.

They hypothesized that the extra iridium was from extraterrestrial sources, and that at the time of the Cretaceous-Tertiary extinction there had been a large meteorite (10 km in diameter) that had hit the Earth. The dust from the impact would have gone into the atmosphere, causing total darkness for several months, inhibiting photosynthesis and cutting the food chain at the base. Other effects of the impact would have been extreme cold, heat and also acid rain. Other evidence for impact, such as shocked minerals, was found in Italy and in another 100 sites around the world, which made plausible the global mass extinctions.

Against this hypothesis is the fact that the crater of the impact has not been found, which may mean that it occurred in the ocean and that part of the ocean has been subducted—it has moved underneath a ridge in plate tectonic activity.

This hypothesis led to findings of many impact craters and also of other boundaries associated with iridium anomalies. It also generated interest in extinctions that seemed to repeat themselves periodically.

A study by two paleontologists from Chicago showed that there was a certain cyclicity to extinctions occurring every 26–28 million years. This led Rich Muller, an astrophysicist at U.C. Berkeley, to hypothesize that the Sun has a companion star, Nemesis, which orbits around the Sun in a tulip orbit with a period of 26–28 million years and that at its perihelion it disturbed a belt of comets and asteroids outside the Solar System. This sent comets and asteroids into the inner Solar System and caused periodic comet showers on the Earth, and as a consequence, periodic extinctions.

The original statistical data showing periodicity in mass extinctions were sketchy and poorly constrained. To base Nemesis on it was an exercise in creativity—the search for Nemesis has so far been unsuccessful.

VOLCANISM

For many a geologist, accepting a catastrophic extraterrestrial event has been difficult, so, two Earth scientists from Dartmouth University proposed that the extra iridium came from big volcanic eruptions occurring at the same time as the extinctions. This was hypothesized because iridium was found in the gases

emitted by Kilauea. A candidate for the big volcanic event that would have sent the iridium and dust in the atmosphere to stop photosynthesis and kill the dinosaurs would be the Deccan Traps of India, a big basaltic eruption dated at 66 million years. However, no evidence of iridium has been found in the Deccan Traps, and the type of volcanic eruption of these basalts was quiet and not violent enough to send material into the stratosphere to orbit around the Earth (as required by the global distribution of iridium). It also would not produce impact minerals, although some scientists claim it does (no evidence has been uncovered as to this effect). Volcanism may have had something to do with local extinctions, but not at a global level.

GLACIATIONS

Finally, many argue that climatic fluctuations and changes in sea level could have caused sudden extinctions. Although there are data to support contemporaneous extinctions and climatic changes, it is hard to see how gradual changes in the climate, changes in sea level and slow glaciation, and interglaciation periods could have caused sudden mass extinction of all types of animals, even those used to living in cold climates.

HUMAN CIVILIZATIONS AND TECHNOLOGY

The developments—and disintegrations—of civilizations span thousands of years, encompassing spectacular advances in knowledge and sharply disruptive disturbances on the human and planetary scale. This section will encapsulate the development of human endeavor from the Paleolithic to the Atomic Ages, outlining the technological movements that have accompanied and spurred the advance of culture.

Civilization is generally regarded as culture with a relatively high degree of elaboration and technical development, often demarcated by the complex of cultural elements that first appeared in human history 6,000 to 8,000 years ago. At that time, on the basis of agriculture, stock-raising and metallurgy, intensive occupational specialization began to appear in the river valleys of SW Asia. However, the roots of those circumstances long predate that period in several parts of the prehistoric world: Mesopotamia, Egypt, China, Greece, India, Highland Peru, and elsewhere.

THE OLD STONE AGE (PALEOLITHIC)

The specific characteristics of civilization—food production, plant and animal domestication, metallurgy, a high degree of occupational specialization, writing and the growth of cities—had their origins in the the Old Stone Age, the earliest period of human development and the longest phase of humanity's history.

The Old Stone Age is approximately coextensive with the Pleistocene geologic period, beginning about two million years ago and ending in various places between 40,000 and 10,000 years ago, when it was succeeded by the Mesolithic Period.

By far the most outstanding feature of the Paleolithic period was the evolution of humans from an apelike creature, or near human, to true Homo sapiens. This development was exceedingly slow and continued through the three successive divisions of the period, the Lower, Middle and Upper Paleolithic.

The most abundant remains of Paleolithic cultures are a variety of stone tools whose distinct characteristics provide the basis for a system of classification containing several toolmaking traditions or industries. The oldest recognizable tools made by members of the family of humankind are simple stone choppers, such as those discovered at Olduvai Gorge in Tanzania. These tools may have been made over one million years ago by Australopithecus or by Homo habilis. Fractured stone "tools" called **eoliths** have been considered the earliest tools, but it has been difficult to distinguish human-made from naturally produced modifications in such stones.

THE LOWER PALEOLITHIC

Lower Paleolithic stone industries of Homo erectus have been found at various sites in China, Europe, Africa and Asia dating from 100,000 to 500,000 years ago. The stone tools of this period are of the core type, made by chipping the stone to form a cutting edge, or of the flake type, fashioned from fragments struck off a stone. Hand axes were the typical tool of these early people, who were hunters and food gatherers.

THE MIDDLE PALEOLITHIC

The Middle Paleolithic period is often associated with Neanderthals, living between 40,000 and 100,000 years ago. Neanderthal remains are often found in caves with evidence of the use of fire. Neanderthals were hunters of prehistoric mammals and their cultural remains, though unearthed chiefly in Europe, have also been found in N Africa, Palestine and Siberia.

Stone tools of this period are of the flake tradition, and bone implements, such as needles, indicate that crudely sewn furs and skins were used as body covering.

THE UPPER PALEOLITHIC

The Upper Paleolithic saw the disappearance of Neanderthal in favor of other Homo sapiens such as Cro-Magnon. The beginnings of communal hunting and fishing are found here, as is the first conclusive evidence of belief systems centering on magic and the supernatural. Pit houses, the first human-made shelters were built, sewn clothing was worn, and sculpture and painting originated. Tools were of great variety, including flint and obsidian blades and projectile points.

The final and perhaps most impressive phase of the Paleolithic period is the Magdalenian period, in which communities of fisherman and reindeer hunters used highly refined and varied tools and weapons, and left an impressive array of cave paintings.

THE MESOLITHIC PERIOD

This period began with the end of the last glacial period and involved the gradual domestication of plants and animals and the formation of settled communities at various times and places, some overlapping into the considerable development of the Neolithic period.

Characteristic of the period were hunting and fishing settlements along rivers and on lake shores. Pottery and the use of the bow began to develop. Hafted axes and bone tools were found in the Baltic region and N England, demonstrating strong advances over Paleolithic crudity.

The Mesolithic period in several areas shows a gradual transition from a food-collecting to a food-producing culture.

THE NEOLITHIC REVOLUTION

Toward the end of that last ice age, some 15,000 to 20,000 years ago, a few of the human communities that were most favored by geography and climate began to make the transition from the long period of Paleolithic savagery to a more settled way of life depending on animal husbandry and agriculture.

This period of transition led to a marked rise in population, to a growth in the size of communities, and to the beginnings of town life. It is sometimes referred to as the Neolithic Revolution because the speed of technological innovation increased so greatly and the social and political organization of human groups underwent a corresponding increase in complexity.

The earliest known development of Neolithic culture was in SW Asia between 8000 B.C. and 6000 B.C. Settled villages cultivating wheat, barley and millet and raising cattle, sheep, goats and pigs expanded. Neolithic culture and its innovations spread through Europe, the Nile valley, the Indus valley (India) and the Yellow River valley (China).

By 1500 B.C., Neolithic cultures based on the cultivation of maize, beans, squash and other plants were present in Mexico and South America, leading to the rise of the Inca and Aztec civilizations and spreading to other parts of the Americas by the time of European contact.

THE BRONZE AGE

This is the period in the development of technology when metals were first used regularly in the manufacture of tools and weapons. Pure copper and bronze, an alloy of copper and tin, were used indiscriminately at first; this early period is sometimes called the Copper Age.

The earliest use of cast metal can be deduced from clay models of weapons; casting was certainly established in the Middle East by 3500 B.C. In the New World, the earliest bronze was cast in Bolivia A.D. c.1100. The Inca civilization used bronze tools and weapons but never mastered iron.

The development of a metallurgical industry coincided with the rise of urbanization. The organized operations of mining, smelting, and casting undoubtedly required the specialization of labor and the production of surplus food to support a class of artisans, while the search for raw materials stimulated the exploration and colonization of new territories.

THE IRON AGE

This period begins with the general use of iron and continues into modern times. The use of smelted iron ornaments and ceremonial weapons became common during the period extending from 1900 to 1400 B.C. About this time, the invention of tempering, the strengthening of a metal by the application of heat or by alternate heating and cooling, was made in the Hittite empire. After its downfall in 1200 B.C., the great waves of migrants spreading through S Europe and the Middle East ensured the rapid transmission of iron technology.

The casting of iron did not become technically useful until the Industrial Revolution. The people of the Iron Age developed the basic economic innovations of the Bronze Age and laid the foundations for feudal organization. Ox-drawn plows and wheeled vehicles acquired a new importance and changed the agricultural patterns. For the first time humans were able to exploit efficiently the temperate forest. Villages were fortified, warfare was conducted on horseback and in horse-drawn chariots, and alphabetic writing based on the Phoenician script became widespread.

CLASHES, CONQUESTS, AND CHANGE

Technical advances in weaponry and warfare helped an insignificant pastoral settlement in Rome to become perhaps the world's most successful empire—supreme as a lawgiver and organizer, holding sway over virtually all the then-known world.

From the establishment of the Roman republic around 500 B.C. successive generations of Roman rulers expanded their territorial acquisitions, and thus absorbed and exported the leading material, social and intellectual advances of the day.

From the age of Caesar, (60 B.C.) Rome was foremost as the civilizer of barbarians and the ruler of the older world. The empire promulgated the ideals of Greek literature, architecture and thought. The extensive system of Roman roads made transportation easier than it was again to be until the development of railroads. A postal service was organized; commerce and industry, particularly by sea, were greatly developed.

At its height, imperial Rome counted well over one million inhabitants. It was well-policed, sanitation was excellent, and among the rich, such luxuries as central heating and running water were not unknown. Decline came quickly, however. In 476 the last emperor of the West, appropriately called Romulus Augustus, was deposed by the Goths; this date is commonly accepted as the end of the West Roman Empire, or Western Empire.

The so-called Dark Ages that followed in Western Europe could not eradicate the profound imprint left by Roman civilization.

THE INDUSTRIAL REVOLUTION

This term is usually applied to the social and economic changes that marked the transition from a stable agricultural and commercial society to a modern industrial society relying on complex machinery rather than tools. Historically, it refers primarily to the period in British history from the middle of the 18th century to the middle of the 19th century. Dramatic changes in the social and economic structure took place: inventions and technological innovations created the factory system of large-scale machine production, greater economic specialization emerged and the laboring population, formerly employed predominantly in agriculture (where production was also on the rise), increasingly gathered in great urban factory centers. The same process occurred at later times and in changed tempo in other countries.

There has been much objection to the term because the word "revolution" suggests sudden, violent, unparalleled change, whereas the transformation was, to a great extent, gradual. Some historians argue that the 13th and 16th centuries were also periods of revolutionary economic change. The ground was prepared by the voyages of discovery from Western Europe in the 15th and 16th centuries, which led to a vast influx of precious metals from the New World, raising prices, stimulating industry, and fostering a money economy. Expansion of trade and the money economy stimulated the development of new institutions of finance and credit.

In Britain's productive process, coal came to replace wood. Early model steam engines were introduced to drain water and raise coal from the mines. Factories and industrial towns sprang up. Canals and roads were built, and the advent of the railroad and the steamship widened the market for manufactured goods. The Bessemer Process made a gigantic contribution, for it was largely responsible for the extension of the use of steam and steel that were the two chief features of industry in the middle of the 19th century. The transformation of the United States into an industrial nation took place largely after the Civil War and on the British model. The Industrial Revolution was introduced by Europeans into Asia,

and the last years of the 19th and the early 20th century saw the development of industries in India, China and Japan.

The Industrial Revolution created a specialized and interdependent economic life and made urban workers more completely dependent on the will of their employers than the rural workers had been. Relations between capital and labor were aggravated, and Marxism was one product of this unrest.

The Industrial Revolution changed the face of nations, giving rise to urban centers requiring vast municipal services. Technology was praised by some factions as the mainspring of social progress and the development of democracy, and criticized by others as the bane of modern man, responsible for the tyranny of the machine and the squalor of urban life.

Machines had vastly increased production, eased the toils of labor and raised living standards, but often at a cost of environmental pollution, depletion of natural resources, and the creation of unsatisfying jobs.

THE ATOMIC AGE

With the advent of the Atomic Age we must face the contemporary dilemma of a highly technological society contemplating the possibility that it could use its sophisticated techniques in order to accomplish its own destruction. It is not a firm assumption to identify technology with the "progressive" forces in contemporary civilization. The forces of technology will continue their seemingly inexorable advance, bringing us in vitro fertilizations, global satellite communications, genetic manipulations and B2 bombers, but the wisdom to manage these innovations is not a guaranteed part of the package.

SimEarth

THEORIES OF THE EARTH: THE GAIA HYPOTHESIS

SimEarth is centered around a hypothesis of the evolution of the Earth, life and atmosphere known as the **Gaia hypothesis**, proposed by James Lovelock. The Gaia hypothesis is a holistic approach to understanding life and natural phenomena as teleological circumstances, that is, as existing because they fill a purpose and not just because of happenstance. Here is a brief explanation of what the Gaia hypothesis is and a few of the examples given by Lovelock.

SYSTEMS

Before we start talking about Gaia we need to define what the feedback mechanisms "positive" and "negative" mean. A positive feedback loop is also known in systems theory as a vicious circle or catastrophic loop. As illustrated in Figure 20, a positive loop is the one that causes continuous increase or decrease of a certain condition resulting in a catastrophe. A negative feedback loop is a self-regulating feedback loop or virtuous circle: a mechanism like a thermostat, where if a certain condition increases, the next decreases, resulting in equilibrium or self-regulation.

Figure 20 Positive and Negative Feedback Loops

Most of Earth's systems, like the carbon cycle and the atmospheric hydrologic cycle, are self-regulatory and tend toward equilibrium. Nonetheless, most systems can be driven over the edge and would never be able to self-regulate again if a certain critical threshold of one of the conditions is reached. This could happen with atmospheric CO_2.

GAIA

The Gaia hypothesis comes in two versions: the weak Gaia and the strong Gaia. The strong Gaia says that the Earth is alive. The weak Gaia says that life may have some regulatory effect on some of the dynamic systems of the planet. We will explore in this manual only the strong Gaia version. Please understand that although this hypothesis is controversial and therefore not generally accepted in the scientific community, it provides a useful framework for understanding the Earth.

Gaia was developed by Lovelock during the time NASA was preparing the Viking explorer for a trip to Mars. He was designing instrumentation to test if there was life there. But in order to test for life, Lovelock had to ask the question, "What is life?" This work provided Lovelock the opportunity to reevaluate this fundamental question.

Lovelock realized that we needn't go to Mars to find out if there was life, because if there were, we would see changes reflected in its atmospheric composition and other planetary features like those we see on the Earth, which has a very peculiar atmosphere. Life as we know it would affect the planet's atmosphere, as shown in Table 5.

GAS	VENUS	EARTH (without life)	MARS	EARTH
CO_2 (%)	96.5	98	95	0.03
N_2 (%)	3.5	1.9	2.7	79
O_2 (%)	trace	0.0	0.13	21
Ar	70. ppm	0.1	1.6	1
Methane	0.0	0.0	0.0	1.7 ppm
Surf. Temp.	459° C	240-340° C	-53° C	13° C
Total Pressure	90 bars	60 bars	.0064 bars	1.0 bars

Table 5 Origin of Atmospheric Composition

DAISYWORLD

Lovelock invented a very simple world model called Daisyworld to explain the tenets of the Gaia hypothesis. The parable of Daisyworld begins by explaining that it is a fictitious planet in which the life is represented by different-colored daisies: dark, light and neutral colors.

The planet is at the same distance from the Sun as the Earth, is the same size as the Earth and has a little more land area than the Earth. On this planet there is enough CO_2 for daisies, but it does not affect the climate like on the Earth and clouds do not exist.

The Sun increases its heat output with age. The optimum temperature for daisies is about 20° C. If the planet gets colder than 5° C, daisies will not grow. If it gets hotter than 40° C, they will die.

The average temperature of the planet is determined by the albedo, which is determined by the color of the daisies. A dark daisy absorbs more heat and the temperature rises; a lighter daisy reflects more heat and the temperature falls. This effect will make white and dark daisies alternate in population size until they eventually reach equilibrium, a condition in which all acting influences are cancelled by others resulting in a stable, balanced, or unchanging system. The

effect will also control the temperature of the planet. When the Sun gets hotter the temperature cannot be regulated anymore by the daisies and they die—the planet becomes barren.

The Daisyworld model illustrates the following tenets of the Gaia theory:

1. Living organisms grow vigorously, exploiting any environmental opportunities that open
2. Organisms are subject to the rules of Darwinian natural selection
3. Organisms affect their physical and chemical environment, by breathing, for example
4. Limits of constraints and bounds establish the limits of life

A version of the Daisyworld program is included as one of the SimEarth scenarios. There is a complete discussion of how and why Daisyworld works in the "Scenarios" chapter.

EVIDENCE OF REGULATION BY LIFE

Lovelock's book, *The Ages of Gaia*, examines the pollution of the atmosphere by oxygen producers and its consequences.

Many nations are extremely concerned about global warming, but it is not clearly understood how the Earth regulates the amount of CO_2 in the atmosphere. From the very beginning of life, CO_2 has been important in providing food for photosynthesizers, and as the thermal cover to keep us warm. Biota (life) pumps CO_2 from the atmosphere; its level has been going down for the last 3.6 billion years.

The increase in CO_2 due to the burning of fossil fuels is not much more than a minor disturbance to the Earth, but tends to offset the decline. Even though the quantities humans add may be small, if the CO_2 regulatory mechanism is reaching its capacity, then the plants that evolved as the CO_2 levels declined through Earth's history may be affected. Also, the rapid rise of CO_2 levels since the Industrial Revolution may indicate that the regulatory pumps are not working properly to remove the excessive CO_2 from the atmosphere.

This change in CO_2 is similar to the one that occurred naturally from the last ice age, so it may affect the climate as much as between the last ice age and now. We do not know enough about the CO_2 system to predict if the perturbation will self-regulate, cause oscillations, chaotic changes or total failure.

The possible climactic changes due to the increase in CO_2 probably won't have tragic consequences for the Earth and life as a whole, but it may wipe out humanity along with many other species of plants and animals.

REFERENCES

GEOLOGY

1. Francis, Peter, 1976, **Volcanoes**, Penguin Books, England
2. Press, F. and Siever, R., 1986, **Earth**, fourth edition, Freeman, New York
3. Skinner, B.J., and Porter, S.C., 1989, **The Dynamic Earth**, J. Wiley and Sons, New York
4. Uyeda, S., 1978, **The New View of the Earth**, Freeman, New York

CLIMATE

1. Iribarne, J.V., and Cho, H., 1980, **Atmospheric Physics**, Reidel Publishing Co., Holland
2. Neiburger, M., Edinger, J.G., and Bonner, W.D., 1982, **Understanding Our Atmospheric Environment**, Freeman, New York
3. Riehl, H., 1978, **Introduction to the Atmosphere**, McGraw-Hill, New York
4 Ross, D., 1988, **Introduction to Oceanography**, Prentice-Hall, New Jersey

LIFE

1. Lane, G., 1978, **Life of the Past**, Charles Merrill Publishing Co., London
2. McAlester, A.L., 1977, **The History of Life**, Prentice-Hall, New Jersey
3. Muller, R., 1988, **Nemesis, the Death Star**, Weidenfeld and Nicolson, New York

GAIA

1. Lovelock, J., 1988, **The Ages of Gaia**, Norton, New York
2. Myers, Norman, 1984, **Gaia, an Atlas of Planet Management,** Anchor Press, New York

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APPENDICES

"The greatest planets of mice and men oft go extinct."

PROBLEMS AND SOLUTIONS

Here is a listing of common problems and challenges you will face, their causes, and some suggestions on how to deal with them.

PLANET OVERHEATING

First, check CO_2 levels. If high, use Oxygenator, or increase Biomes to reduce CO_2 levels.

You can also turn down solar input, raise cloud albedo, and turn down greenhouse effect.

EVOLUTION IN THE WATER SEEMS TO STOP

Most advanced aquatic life forms live in shallow water. If there are not enough shallow shelves, you will hit an evolutionary dead-end. You can create shelves either by raising the ocean floor or lowering the land. You can raise the ocean floor with the SET ALTITUDE tool or with volcanos. You can lower the land with the SET ALTITUDE tool or with meteors.

"... NEEDS ENERGY"

If you see a message that says that one of the disciplines (Philosophy, Science, Agriculture, Medicine, Art/Media) needs energy, increase their share of energy in the CIVILIZATION MODEL CONTROL PANEL, or increase the overall level of energy.

Overall energy is increased by doing more work, by increasing population, and by concentrating on the most efficient energy sources.

METEOR STORM

This is a warning that extinctions are imminent. There's not much to be done except prepare for the worst and get ready to rebuild your biomass.

MASS EXTINCTIONS

Mass Extinctions are caused by too much dust or too little oxygen (<20%) in the atmosphere.

Dust is put into the atmosphere by volcanos and meteor impacts. Nothing but time removes dust from the atmosphere.

If oxygen levels are below 20%, use the Oxygenator terraforming tool, or increase biomes.

FUELS RUNNING LOW

This is a warning that war is imminent. Change your energy usage to conserve fuels.

NUCLEAR DETONATIONS

Nuclear war is in progress. In SimEarth, this is caused by competition for limited nuclear fuels. Reduce investment in nuclear energy to halt the wars.

NUCLEAR WINTER

Caused by the radiation and dust in the air that result from numerous nuclear explosions. Cut back on fuel usage, and concentrate on keeping small pockets of your sentient species alive. Eventually the dust will settle and the radiation zones will vanish. Tidal waves can help clean up radiation in the oceans and on the shores.

POLLUTION

Pollution comes from industrial age technologies, as well as fossil fuel usage. The best solution is to invest in science and advance to the atomic era as quickly as possible.

GLOSSARY

Aerobic — Requires oxygen. This can apply to animals, machines or processes.

Air Pressure — The pressure caused by air molecules bouncing against a surface. Vacuum has no air pressure.

Albedo — The reflectivity of a surface. A surface with high albedo will reflect sunlight. A surface with low albedo will absorb sunlight. Snow (high albedo) reflects sunlight and remains cold.

Anaerobic — Does not require oxygen. This can apply to animals, machines or processes.

Arctic — Areas that are snow or ice covered. Cold and dry. See Tundra.

Arthropod — The phylum of animals which includes insects, crustaceans, arachnids, and myriapods.

Atmosphere — The blanket of gases which envelop a planet.

Atomic Age — This era is characterized by Nuclear Power, Aircraft, Radio, and Chemical Fertilizers.

Axis — The planetary center of rotation. On Earth, the axis is a line passing from the north pole to the south pole.

Biomass — The total dry weight of all living material on a planet.

Biome — A major ecosystem such as temperate grassland, forest or desert.

Biome Factory — A SimEarth tool which produces the best biome for the environment it occupies.

Biosphere — The areas of a planet which are inhabited by life. On Earth this is the crust, hydrosphere, and lower atmosphere.

Boreal — Also known as Boreal Forest. Biome designed for cool regions with airborn moisture. The trees are usually conifers.

Bronze — An alloy of tin and copper that is stronger than either.

Bronze Age — This era is characterized by bronze tools, sail ships, clay tablets and irrigation.

Carbon Dioxide (CO_2) — A gas composed of two oxygen atoms and one carbon atom. This gas is used by plants in photosynthesis and produced by organisms as they respirate.

Carniferns — A SimEarth name for mobile, carnivorous plants. The Venus Flytrap is the precursor to carniferns.

Cetaceans — The order of mammals that is exclusively aquatic. This includes dolphins and whales.

CO_2 Generator — A SimEarth tool that creates carbon dioxide for the atmosphere.

Class — The classification of life under Phylum. The major classes of Chordata are fish, amphibian, reptile, avian, and mammal. See Order.

Cloud Albedo — The albedo of clouds. High cloud albedo can keep Earth cool. See Albedo.

Conifer — Cone-bearing trees and shrubs. This includes evergreens, pines and firs.

Continental Drift — The theory that continents have changed position on Earth. This is a component of Plate Tectonics.

Core — The extremely dense, fluid center of Earth. It is probably composed of molten iron. See Mantle.

Crust — This thin outer shell of the Earth is only a few miles deep. See Mantle.

Cryosphere — The frozen regions such as the icecaps, tundra, and mountain glaciers.

Desert — An ecosystem suited for hot weather and little water.

Dry Weight — The mass of an organism after the water has been removed.

Dust — In SimEarth, dust refers to airborne dust, ash and detritus. This can darken a planet, reducing photosynthesis and absorbing heat.

Ecosystem — A group of plant and animal species living together in rough balance.

Eukaryote — Single-cell microbes with a nucleus.

Evolution — The process by which life has changed and diversified.

Explosive Upwelling — Sometimes hot spots are very hot. This can lead to a volcano that is a thousand times the size of any seen by man. These upwellings spew the material for continents and are possibly Nemesis.

Extinction — The elimination of one species.

Geosphere — See Lithosphere.

Greenhouse Effect — Planetary heating induced by greenhouse gases.

Greenhouse Gases — Certain gases will let solar radiation enter the atmosphere but not leave. The most common of these are carbon dioxide, methane, and water vapor.

Hot Spot — Mantle material flows up and down as well as sideways. Hot magma sometimes rises from the core to the crust creating a Hot Spot. See Volcano.

Hydrosphere — The water portions of Earth. This includes oceans, lakes, rivers, and clouds. SimEarth restricts the term to oceans.

Industrial Age — This era is characterized by the use of fossil-fuel engines, automobiles, telephones, and animal husbandry.

Information Age — This era is characterized by computers, global communications, robotic labor, and ecologic awareness.

Insolation — INcoming SOLar radiATION.

Iron Age — This era is characterized by iron tools, sextants, paper, the printing press, and horse-drawn plows.

Kingdom — The most general classification of life in Biology. The five kingdoms are prokaryotae, protoctista (eukaryotes), fungi, plantae and animalia.

Jungle (Tropical Forest) — A biome that thrives in hot, wet climates.

Lava — The lighter materials of magma that come to the surface via volcanos and upwellings.

Lithosphere — The rock portions of the planet: Plates, Crust, Moho, Mantle, and Core.

Magma — Molten rock found beneath the Earth's crust. See Lava.

Mantle — The layer of magma between the crust and core of the Earth. This area is constantly flowing at a speed measured in centimeters per year.

Mass Extinctions — At various times in Earth's history large numbers of species have vanished. Records indicate that at each of these times between 5% and 50% of the species became extinct. See Nemesis.

Methane (CH_4) — A gas composed of one carbon atom and four hydrogen atoms. It is primarily produced by primitive microbes which currently live in the intestines of larger organisms.

Microbe — A single-celled organism.

Mollusk — Class of invertebrates that includes snails, mussels and octopus.

Monolith — A SimEarth tool for advancing life. Thank you Arthur C. Clark.

Moho — Also called the Mohorovicic discontinuity. The turbulent region between the crust and the mantle.

Mutate — When an organism makes an inexact copy of itself. The variability which allows evolution to occur.

N_2 Generator — A SimEarth tool for introducing Nitrogen into the atmosphere.

Nanotech Age — This era is characterized by molecular construction, molecule-sized machines, and completely automatic production.

Nemesis — The culprit in the periodic mass extinctions (every 25 million years or so). Identity unknown, the two prime suspects are: Meteors (caused by a dark star orbiting our Sun) and Explosive Upwellings.

Nitrogen (N_2) — A gas composed of two nitrogen atoms. It is a heavy, stable gas comprising 80% of Earth's atmosphere.

Noosphere — "The sphere of mind" which includes society and culture.

Order — The classification of life under Class. The major orders of mammals are rodents, felines, canines, ruminants, primates and cetaceans.

Organism — An independent unit of life. All plants, animals and microbes are organisms.

Oxygen (O_2) — A gas composed of two oxygen atoms. This is used by organisms when they respirate.

Oxygenator — A SimEarth tool that converts carbon dioxide to oxygen.

Photosynthesis — A process that uses light to create energy-storing chemicals such as sugar. Oxygen is a byproduct of photosynthesis.

Plant — An organism that uses photosynthesis to feed itself.

Plate — A solid piece of the Earth's crust being pushed about by flowing mantle.

Plate Tectonics — Theory that the Earth's crust is formed of mobile plates sliding across the mantle. Even the ocean bottoms consist of plates.

Phylum — The classification of life under Kingdom. The major animal phylums are chordates, arthropods and invertebrates. See Class.

Phytomass — The total dry weight of all plant material on a planet.

Planet — An astral body that orbits a sun.

Planetesimal — An small planet. Small usually means moon-sized or less.

Prokaryote — Primitive single-cell microbes with no nucleus.

Radiate — The class of invertebrates including jellyfish and starfish.

Sapient — An intelligent, tool-using organism.

Stone Age — This era is characterized by stone tools, domestication, fire, and cultivation.

Surface Albedo — In SimEarth this refers to the albedo of your planetary surface.

Swamp — Also known as tropical grasslands. This biome is composed of plants and animals that thrive in slow shallow water and on muddy shorelines.

Terraform — The process of modifying an entire planet for a particular purpose.

Trichordate — A SimEarth term for an order of radiates with three radiating spines.

Tundra — This biome is designed to survive periodic arctic conditions and year-round cold weather.

Upwelling — When two plates pull apart, lava will flow up between them forming small rises like the Mid-Atlantic Ridge. See Plate Tectonics.

Vaporator — A SimEarth tool that stimulates global plant growth.

Volcano — When a Hot Spot is over a thin section of crust, a volcano can erupt. Volcanos spew lava and ash over an area, often forming new cone-shaped mountains.

Water Vapor (H_2O) — Water can be a gas with one oxygen atom and two hydrogen atoms.

Zoomass — The total dry weight of all animal material on a planet.

SimEarth

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SIM Farm™

USER MANUAL

by Tom Bentley

Real Farms Section
by Steve Perrin

SIM Farm

MAXIS
2121 N. California Blvd.
Walnut Creek, CA
94596-3572

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INTRODUCTION

When tillage begins, other arts follow. The farmers therefore are the founders of human civilization.

— Daniel Webster,
Remarks on Agriculture,
January 13, 1840

SIM Farm

INTRODUCTION

WELCOME

Welcome to SimFarm, where you are rewarded for the fertility of your imagination as well as your fields. SimFarm is a dynamic, responsive farming simulation that lets you experience starting a farm from the ground up (and down). Each crop has its own planting, growing and harvesting needs, and responds to the soil quality of your fields, your farming skills, and seasonal changes. A host of prebuilt scenarios is included to offer varying degrees of challenge.

Since SimFarm, like all Maxis simulations, doesn't force you along a linear, predetermined path, the best way to succeed is to experiment. Try anything and see what happens. If your crops fail in one field, plant another crop or another field. If those skies aren't cloudy enough, hedge your bets by selling to the futures market. If your crops and machinery can't weather the weather, you can take out a loan from the bank. (But there's no free lunch in SimFarm—even if you've grown it. Those loan officers will come calling.)

Once you become an expert in your field, you can take many approaches to running your farm. You can concentrate on crop production, animal husbandry, environmental friendliness or the amassing of wealth—but remember: you reap what you sow. Of course, all of your farming knowledge might not be worth a hill of beans if disaster strikes, though you might fetch a tidy profit off the beans.

MANUAL AND ADDENDUM

This manual contains all the information needed to play SimFarm on any computer. A separate machine-specific Addendum/Quick Start Guide gives all the details for installing and starting SimFarm on your particular computer.

GROW FORTH

For now, step into the Tutorial, take a deep breath of that rural air and crumble some earth between your fingers—the sun's coming up and there's work to do.

SIM Farm

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CREDITS

THE PROGRAM
Concept, Design and Programming: Eric Albers
Producer and Additional Design: Michael Perry
Computer Art Director: Jenny Martin
Computer Art: Suzie Greene, Bonnie Borucki, Sharon Stambaugh, Donna Buttlaire, Sharon Perry, Mary Schewe, Maureen Gilhooly
Sound: Eric Albers, Michael Perry
Sound Programming: John Miles, Brian Conrad
Music: Sue Kasper
Technical Director: Brian Conrad
Installer Programming: Andrei Snegov
Data Research: Kathleen Robinson
Something Somewhere Somewhen: Mitzi McGilvray

THE MANUAL
Written By: Tom Bentley
Real Farms Section Written By: Steve Perrin
Editing: Michael Bremer, Debra Larson
Design and Layout: Vera Jaye, Kristine Brogno
Contributions to Documentation: Michael Perry, Kathleen Robinson

THE PACKAGE
Package Design: Jamie Davison Design, Inc.
Package Illustration: Laura Smith

THE MAXIS SUPPORT TEAM
Lead Tester: Don-Jah Horat
QA: Alan Barton, Manny Granillo, Chris Weiss, Roger Johnsen
Tech Support: Carter Lipscomb, Kevin O'Hare, Peter Alau, Chris Blackwell
Product Manager: Larry Lee
Public Relations: Sally Vandershaf
Manufacturing: Val Garcia, Kim Vincent

THANKS TO:
Jeff Braun, Joe Scirica, Don Walters, Jim Siefert, Brian Conrad, Andrei Snegov, Bob Derber, Mr. Green Jeans, and Maxine

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TUTORIAL

As a work of art, I know few things more pleasing to the eye, or more capable of affording scope and gratification to a taste for the beautiful, than a well-suited, well-cultivated farm.

— Edward Everett,
address at Buffalo, New York,
October 9, 1857

SIM Farm

TUTORIAL

WARMING UP THE FARM

OK farmers, here's your chance to get your nails dirty and your feet wet. We'll stroll your property, plow and plant, and bring your first harvest to table. This tutorial will ground you in all the SimFarm basics and introduce a number of the advanced features of the game. When you're ready for details on every command, window and menu item, they'll be waiting for you in the Reference section.

If you haven't already installed SimFarm on your hard disk, you should do so now. See your machine-specific Addendum for complete installation and starting instructions.

Start SimFarm.

Take a moment and be appreciatively dazzled by Maxine, the moovie star of the title screen.

Click anywhere.

You'll be ushered into the Select A Region window, which displays a fine map of our intrepid country. The map's zones will roughly correspond to weather regions in the U.S. Clicking on an area of the map will display the average Rainfall, Temperature and Wind Speed for that chosen region, measured from Low to High on the bar gauges to the map's left. The eight highlighted areas are preset scenarios, with farms in various stages and conditions. We won't concern ourselves with them now.

The four buttons in this window present a wealth of opportunities: You could choose USE THIS REGION after you've made your map selection, putting your (mouse) feet on that ground. DESIGN YOUR OWN grants you customization powers over your farm landscape. LOAD A SAVED GAME lets you load in previously saved SimFarm games. Clicking on QUIT wouldn't make a whole heck of a lot of sense right now, since it will end our flowering relationship.

Click on DESIGN YOUR OWN.

The Design Your Terrain window will open with an aerial view of your proposed game terrain, and a number of functions for altering that terrain. The terrain is different each time it is generated, so your terrain won't look exactly like the one here—but all of the other window features will be the same. Notice the **"T"** and **"H"** somewhere in the terrain. These show where the town and your homestead are located.

The three bar gauges to the left of the terrain control the Rainfall, Temperature, and Wind Speed. Click on the up or down buttons to change the settings.

Go ahead now and play with the bars for a while. Stop when you feel like it.

Below the weather bars are two buttons, RIVER and LAKE. Click on RIVER if you want a river near your farm, and LAKE if you want a lake. What the heck—let's be water hounds.

Click on both buttons.

Now, click on GENERATE WORLD. Your computer will build you some country. Look over the lay of the land for a second or two, until you're ready to start your new farm. If things aren't up to your exacting standards, you can click on GENERATE WORLD again and again until you're happy.

Click on PLAY!

GETTING BACK TO THE LAND

Now you're treated to a couple of window views of your farmland—it may look a mite bleak at the moment. Don't click anywhere on the terrain yet—we're going to tour your screen first.

Note: While the game is running, a number of message windows will pop up. These messages will be useful later, but for now just click on their OK buttons to make them go away.

Another Note: The Evaluation window will pop up every year in the first week of January. For now, just give it a quick glance then click on the CLOSE button. We'll talk more about it later.

At the top of the screen is the menu bar. The menus let you control most of SimFarm's features and functions. Just to prove the point, let's turn off disasters to keep them from crashing this tutorial party.

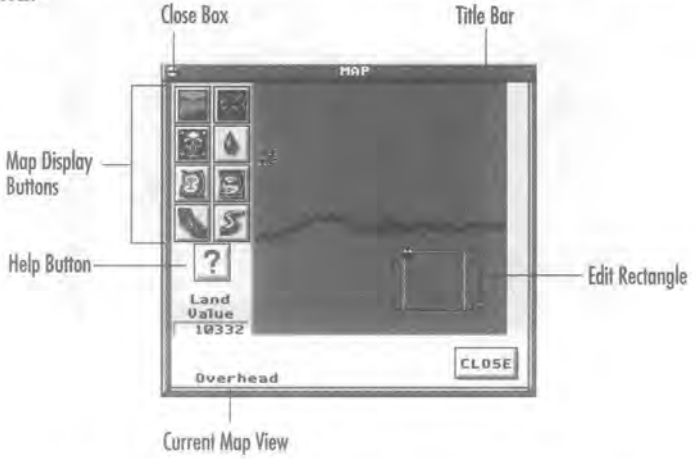
Click and hold on the Disasters menu to open it, then select DISABLE.

Below the menu bar is a row of buttons that let you quickly and easily open each of SimFarm's windows. To the right of the buttons are three icons that show today's weather (first icon) and the weather for the next two days. To the right of the weather icons you will see the current date (week, month and year), and your stash of cash—your available funds.

At the moment, there are two windows on the screen. In front is the little Map window, a condensed overview of the total terrain. Behind it is the larger Edit window, where you will conduct most of your farm business. Active windows in SimFarm have highlighted title bars, and their associated buttons (below the menu bar) will appear depressed. You can move most SimFarm windows around on-screen by clicking and dragging their title bars.

UNFOLDING THE FARM

Let's get the big picture from a little window—by looking at the Map window. If it is closed, or hidden behind another window, the Map window can be activated by clicking on the button below the menu bar with the map on it, or by choosing Map in the Windows menu.



The highlighted rectangle in the Map window encloses the land seen in the Edit window. Your farm—the land that you currently own—is bound by a handsome fence.

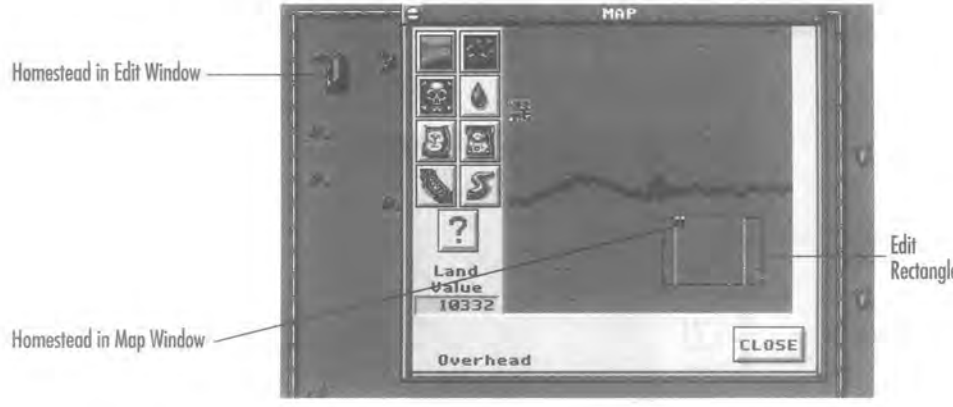
Click anywhere on the terrain in the Map window.

Notice that the rectangle on the map moves to the place where you clicked. The terrain in the Edit window will move to match. This is how you can quickly investigate the lay of the land. Take a minute to skip across the territory to see what you're getting into. There are tiny representations of trees, rocks, rivers and lakes in the Map window, with their big-view counterparts in the Edit window peeking out from behind. You can also move the map rectangle (and the Edit window terrain) by clicking and dragging it with the mouse. When you survey the land, you might see an active little community in the midst of some rather uneventful territory—your local town.

If onion skins are very thin, then winter's mild when coming in. But if onion skins are thick and tough, then winter's long, cold and rough.

Courtesy of Old Farmer's Almanac

Click on your homestead in the map to return the rectangle and the Edit window to your farm.



BUTTON UP

A row of buttons descends along the left side of the Map window. Each of these buttons gives you a different map display with different information about your farm. If you click and hold on the Help button, which looks like a question mark, a display will appear, telling you what each button does. The name of the active map is shown at the bottom of the window. Most maps also have an associated color key (pattern key for black and white computers) to help you interpret them.

Click and hold the Help button for a few seconds.

Now click on the Property button (the one with the little landscape picture).

A grid will appear on the map, dividing the total terrain into plots. A plot is the smallest parcel of land that you can buy or sell at a time. On color monitors, the green plots are your homestead, and the blue square is the township. On black and white monitors, these areas won't be green and blue, but they will be marked.

The Property map also has a BUY/SELL button. It will toggle back and forth, depending on whether or not selected land is already yours. It allows you to buy and sell land, though you cannot sell your original homestead. (Think of the children!) The price of individual plots appears in the Land Value box after you click on them. For the moment, leave your land status as is.

Click again on the Property button to return to the Overhead Map view.

Click on the button with the friendly skull and crossbones (Toxic Tommy).

You now see the Soil Toxicity map, showing the general level of harmful chemicals in the soil. Use the key at the bottom of the window to interpret the colors or patterns.

Below the skull is a button that looks like a dress for Margaret Thatcher (sorry). It opens the Soil Nutrients map, and reveals the amount of good nutrients in the soil. Below that is the crop Disease button (resembling a woeful ear of corn). You can guess what that shows.

The top button on the next row displays the Weeds map; the water droplet button shows the Groundwater map, and the "ATM dollar-slot" button displays the Field Profit map. (At this point, since there are no crops growing, this map display won't tell you much.) Last, and hopefully least, the sauntering centipede button displays the Pests map.

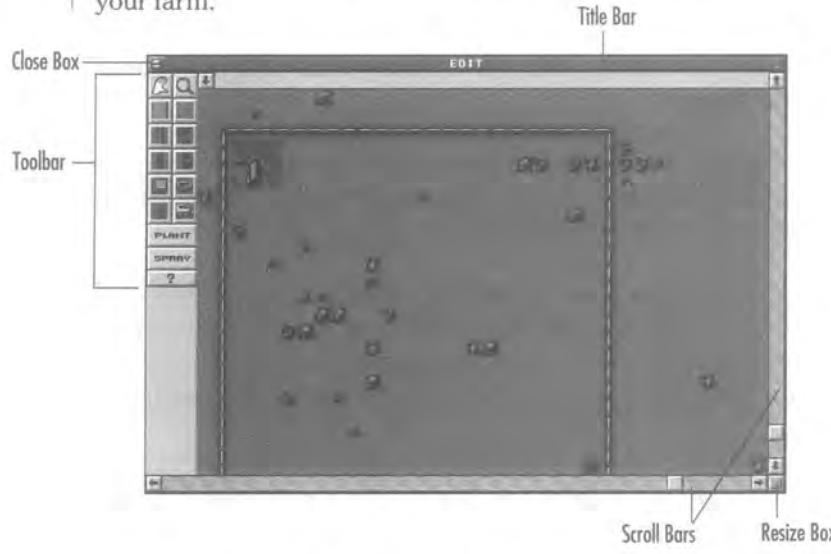
Click the CLOSE button in the Map window.

A type of seaweed called rockweed is harvested from the ocean in Nova Scotia and a type of acid extracted from it is used as a colloidal or sticking agent in jellies, packaged puddings, canned pet food, and hair-styling creams, industrial coatings, surgical dressings, and many more uses.

Courtesy of Old Farmer's Almanac

AT HOME IN THE EDIT WINDOW

You should now be looking at the Edit window. The Edit window has a message ribbon directly below its title bar. The messages that appear here will help guide your farming decisions and will sometimes alert you to quick-changing game conditions. By clicking and holding on the downward-pointing arrow to the left of the messages, you can bring up a small window that displays the game's ten most recent messages, a little history lesson for your farm.

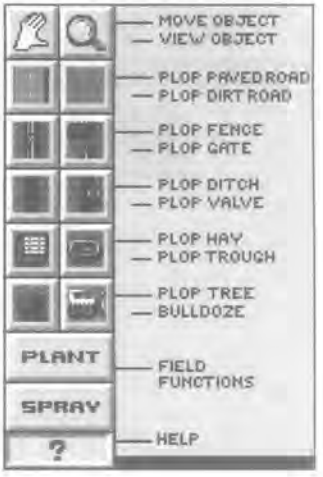


If your property isn't visible in the Edit window, use the scroll arrows to scroll the land until it shows.

On some computers, you can also scroll by moving the mouse pointer to any of the edges of the screen, which will cause the territory to scroll towards the chosen edge. This is called AutoScrolling. It may be a little confusing at first, but you can turn it off by going into the Options menu and selecting AutoScroll, which will toggle it off. If your computer doesn't have AutoScrolling, don't worry about it—unless you enjoy worrying.

HOME, SWEET HOME

The toolbar down the left side of the Edit window is for executing farm commands. Notice the button with a question mark on it. This Help button works just like the one in the Map window—click and hold on it to see an explanation of each of the buttons in the toolbar.



You should now be looking at your property: maybe some rocks, scattered trees, and a rather ramshackle house, all surrounded by a fence. It might look a touch shabby now, but at least you're a homeowner—and developing a prosperous farm will spruce it up. This is your land now, so get to work!

And speaking of work, your farm probably needs a good cleaning. Sometimes you have to get rid of rocks, trees, and other nuisances that clutter up your fields and get in the way. It's time to clean up your property so you can start farming.

Click on the Bulldozer button in the toolbar. Click on or click and drag over all the rocks and trees on your property.

With the AutoDoze option in the Options menu turned on, you can place equipment, roads, buildings, etc. without having to bulldoze obstructions first—but you'll be charged for 'dozing either way.

Note: As you play through this tutorial, you don't have to place your purchases, fields and structures exactly as shown here, but it'll be easier for you if you try to approximate the placements shown.

The following are signs that a severe storm is approaching: Even in broad daylight, robins will get into their nests and stay there; deer and elk will come down from the mountains in great numbers, and cats will feverishly lick them selves, as if possessed.

Courtesy of Old Farmer's Almanac

HOW MUCH IS THAT SILO IN THE WINDOW?

Time to spend some money. When you're playing a real game, you'll want to be a touch more cautious about buying everything all at once. But for this tutorial, we'll be extravagant.

Click on the BUY button below the menu bar to open the Buy window.

Click on the button that looks like a bird's-eye view of a silo.

Clicking on the silo button lets you peruse for purchase various farm structures and stationary equipment. The first item is the silo. You'll see a large picture of a couple of silos, plus a small picture to show you what your purchase will look like once it's placed on your farm. You'll also see a description of the silo, its price, the number of silos you currently own, and a couple arrow buttons.

Click on the arrow buttons to see the various items that you can buy, then return to the small silo.

Click on BUY.

The Buy window will go away (actually it's hidden below the Edit window), and the cursor will change into a dollar sign. The next time you click in the Edit window, a silo will be placed where you click, and the cost of the silo will be deducted from your funds. Choose a place for your silo along the top fence, about halfway between your farmhouse and the right side of your property.

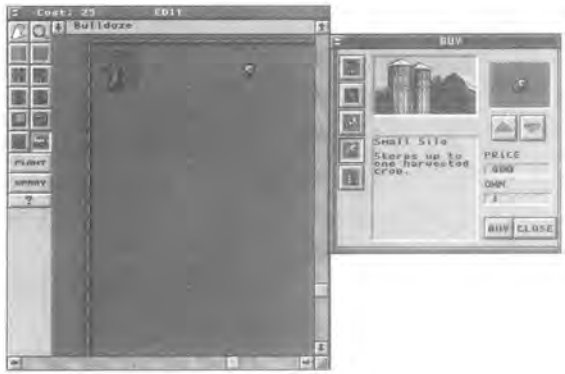
Click to place the silo.

Since we're going on a shopping spree, we want to keep the Buy window readily available. We'll shrink the Edit window and arrange the screen so both the Edit and Buy windows are visible.

Click and hold the Resize box in the lower-right corner of the Edit window, then drag it to your left, so the Edit window fills the left half of the screen, then release the mouse button.

The Buy window should be partly exposed.

Click and drag the Buy window title bar to the right, positioning it so that you can move quickly from making your purchase to placing it on the farm.



Click on the topmost button in the Buy window, the picture of the little tractor.

This reveals all the mobile farm machinery you can buy. The tractor is the first piece of equipment you'll need.

Click the BUY button to buy a tractor, then click next to your house to place it there.

Go back to the Buy window and use the arrow buttons to find a plow.

Buy it and place it near your tractor.

Now buy a few other little necessities: a planter, a sprayer, a harvester, a trailer, and a truck and place them near your other equipment. (Be sure to click the BUY button for each new item.)

It would be a shame if the rain rusted all your new toys, so go back to the Buy window.

Click on the silo button and then on the arrow buttons until you find the large shed.

Buy a large shed and place it to the right of your silo.

Buy a small shed and put it to the right of the large one.

Stored machinery holds its value longer than that exposed to the elements, so let's put our new toys away.

Click on the hand icon in the toolbar.

Your cursor will become a little hand, ready to get a grip on the goods.

Click on your new tractor, then click on your large shed.

The tractor will make itself at home there. Repeat this process, putting all the machinery you just bought into the large shed.

Note: If the game is paused, the tractor and other equipment won't put themselves away. Also, if the path to the shed is blocked, your equipment may get confused and wander around in circles.

After you've put away all your toys, take a look inside the large shed.

Click with the right mouse button (on the Mac, Option-click) on your shed.

The shed's roof will open and you'll see what treasures you've stored.

Right-click (or Option-click) again to re-secure the roof.

You can also store things as you buy them, by clicking on the storage shed itself while placing your equipment purchase.

We know you'll keep your new machinery greased, but the best squeak insurance is a smooth road, and it'll keep that equipment valuable down the line.

Click on the dirt road button on the toolbar.

Click and drag on your farm to run a road just under your sheds, past your house and down the left side of your property line.

Note: You may need to scroll the Edit window a bit while placing your dirt road.

SEEDY BUSINESS

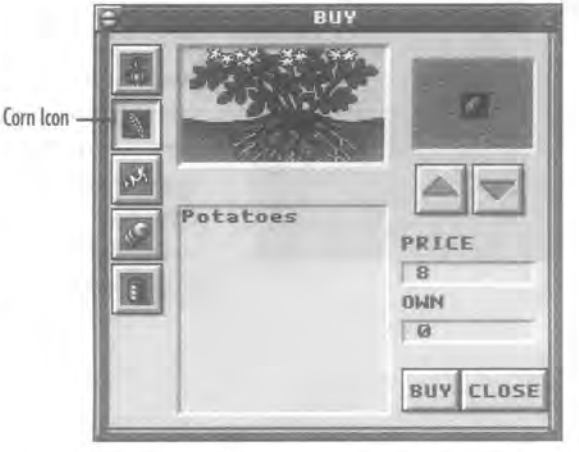
Time to grow some crops. Buying seed is the logical start. Go back to the Buy window and look at the various types of seeds that are available. Use the arrow buttons to check all your choices. We'll buy two units of Potatoes (can you spell that?) and store them in your small shed.

Click on the Corn icon to see the available seeds.

Click on the arrow buttons until you see potatoes.

Click once on the BUY button, and twice on the small shed.

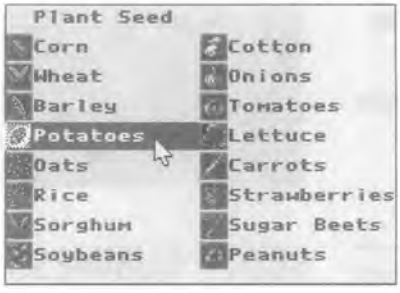
In the future, if you have many fields running and don't want to buy seeds in advance, you can allow AutoBuy (the default selection in the Options menu) to automatically purchase seeds for all fields when necessary. You'll still be charged, but you can catnap through the process.



Close the Buy window and stretch the Edit window to fill your whole screen.

GROW YOUR OWN

Time to plant some taters. Locate the PLANT button in the Edit window toolbar.



Click and hold on the PLANT button, highlight Potatoes and release the mouse button.

The cursor is now a large square. This square represents the potato field that will be placed and planted. Move it around your territory and settle it into the right angle created by your road placement.

Click to place the field.

Voilà!—you're an official farmer. Your tractor will instantly pop into action, plowing your field and then planting your seeds.

Note: If the message bar says that the field can't be placed, make sure you aren't placing it on top of a fence, or on any trees, rocks or equipment. If you place a field, then decide you want it elsewhere, you can bulldoze it, but you'll be charged for 'dozing and new seeds.

You will see a picture of the chosen crop (in this case, potatoes) in the upper-left corner of your field, telling you what's been planted. Your seed will begin to sprout, soon getting as green as your thumb (more or less, depending on the crop—and your thumb). Keep an eye on the game clock to get a sense of how long these events take and keep your other eye on the message bar to interpret if any messages require you to act. You can speed up or slow down game actions by selecting a speed under the Speed menu. (Info icons may pop up occasionally onto your land: a wave indicates the land is flooded, a steer skull that it is very dry, etc.)

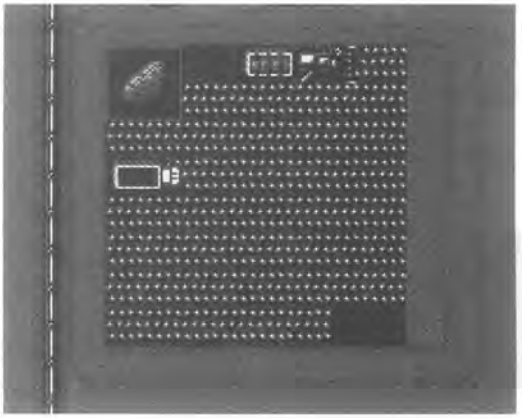
THE ROAD MORE TRAVELED

Let's make the planting and harvesting easier on your machinery by completing your roadwork. Lay the road as shown, so that three sides of the field touch the road and one side has an "open row" between it and the road. Later, we'll come back and put an irrigation ditch in this row.

Click on the dirt road icon.

Click and drag to place a road around your field.

You will see your crop going through the phases of growth, changing color as it approaches harvest time. Harvest cycles depend on the selected crop, but all of them take time. Since you've purchased a harvester and a truck, they'll appear when your crop is ready to harvest and haul away the goods. If you hadn't purchased the equipment, it would have automatically been leased from town, and you'd have been charged for its use. If you don't want a deep outlay of cash when you first begin a game, you can lease all of your equipment—but leasing is expensive. It's good for a quick start-up, but won't be cost-effective over the long run.



Note: For future reference, you must open a space in your fence for rental equipment to enter and leave your farm.

If the cock molts before the hen, we'll have a winter thick and thin; if the hen molts before the cock, we'll have a winter hard as rock.

Courtesy of Old Farmer's Almanac

HAVE A COW(S)

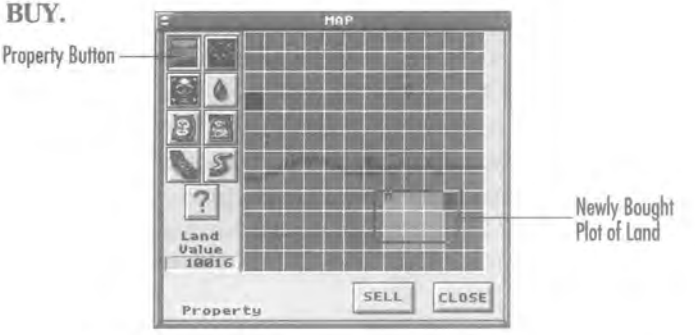
Instead of sitting around watching the grass (or potatoes) grow, let's add a little more life to this farm. First we'll buy some more land, then some cows to make sure you have enough cream for your coffee.

Open the Windows menu and select Map to open the Map window.

Click on the Property button.

Click on a plot of land touching your current holdings.

Click on BUY.



The new purchase will highlight, its cost will be subtracted from your funds, and the BUY button will change to SELL, since you now own the property.

Close the Map window.

Back in the Edit window, you'll see that a tidy little piece of property has been stitched onto your holdings. The fence line is good, because without it those cows you're going to buy will get into your fields and eat your crops. If you ever need to mend your fences or to partition off sections of your property to separate types of livestock, you can use the Fence button in the toolbar and draw on new sections with your mouse. Time to buy some cattle.

Open the BUY window and click on the little cow icon to see the livestock for sale.

Use the arrow buttons, if necessary, to get to the cows.

Click on BUY.

Click in your fenced enclosure six or seven times.

Your new cows will be scurrying about their corral, but they'll soon get plumb tuckered if you don't give 'em some food and water. The Hay icon produces generic food for all animals. The Water Trough button provides tubs of water. Make sure the food and water are in accessible spots. Hungry cows have been known to break through fences (and sometimes end up flattened by farm machinery).

Click on the Water Trough button.

Click a couple times in the corral.

Click on the Hay button.

Click a couple times in the corral.

Of course your livestock need ongoing care. The message bar will warn you when your cows need more food and water. Water troughs go gray when they dry up and hay bales shrink after being nibbled. After a while, you should notice your bossies getting a little bigger (and the food getting smaller) if you keep them fed. If you don't you should notice them getting a little invisible: they'll be dead. You'll want to sell cows and other livestock after a while, because their value drops when they get old. (It's a cruel world.)

Just before a heavy rain, cows will refuse to go out to pasture, dandelions will close up tightly, and seabirds will hang around over land.

Courtesy of Old Farmer's Almanac

By now your potato crop should be harvested or just about ready. If not, relax for a while, you've earned it.

After the harvest, the trucks will transport your crop to your silo, and your land will be cleared and plowed once again. Let's take a look at what your first harvest means to your bank account.

Click on your silo with the right mouse button (Option-click on a Mac).

The contents of the silo will be displayed. There should be a little crop icon indicating your harvest. Now we'll sell the harvest.

Click on the SELL button below the menu bar.

Click on the little Corn icon in the Sell window.

You should see a picture of your crop, and below that its icon, value rating, and current sale price. Its grade, or value, is factored according to soil conditions, weather during the harvest cycle, current market values and the amount of time the crop has been stored after harvest. If you were lucky, it was A-HIGH. If it was less than that, it's probably because your potatoes didn't get enough water.

Click on SELL.

The crop box picture has been replaced by sadly empty storage boxes and barrels, and NOTHING FOR SALE will appear where your crop values were; you should see that your Funds figure has increased by the stated amount. If you wish, you can click on the tractor and cow icons to get a sense of what those items are worth, but don't sell anything now. (Age, poor storage, and poor roads all deteriorate your equipment and lessen its value.)

Close the Sell window.

Now that you have a few more coins, let's see if there are any bargains on water pumps in the BUY window; when dry times come, they're a godsend. First, we'll buy a water pump and place

it on the farmside-edge of the nearest body of water, then run irrigation ditches to your field. Irrigation ditches can't be placed over other objects, so you may need to bulldoze any rocks, trees, or fences obstructing your path.

PLACE THE PUMP

Open the Buy window.

Click on the Silo button to see the stationary buildings and equipment for sale.

Click on the arrow buttons until you find the water pump.

Click the BUY button.

Place the pump next to a river or lake.

Click on the Irrigation Ditch button in the Edit window toolbar.

Click and drag to run the ditch from the pump to your field, and all along the open edge of the field.

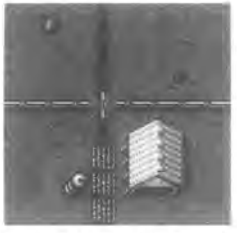
RUN THE DITCH

We'll want to be able to control the water flow in our ditch, so let's add an irrigation valve. You can turn valves on and off by clicking on them with your right mouse button (Option-click for Mac).

Click on the Irrigation Valve button.

Click to place the valve as shown in the picture.

Click on the valve with your right mouse button (Option-click for Mac).



PLACE THE VALVE

Now, even if the weather won't give you a break, you can still go with the flow. If the flood icon shows up in your field, shut off the valve. Your ditch will help disperse the overflow. If the wet weather's in your favor, you can shut down the valves for a bit. And talking about the weather, let's check out the Weather window.

YOU'LL KNOW WHICH WAY THE WIND BLOWS

Click on the Weather window button (weather vane) below the menu bar.

When the three little icons below the menu bar don't meet your meteorological needs, check out this window. It has a dynamic readout of current conditions including the temperature, evaporation rate, average rainfall, wind speed and the five-day forecast.

Close the Weather window.

RECKON ON GETTING A RECKONING

As you must have noticed, the Evaluation window appears automatically at the beginning of each year to give you an overview on your talents as a farmer. You can also access it yourself, by clicking on the thumbs-up/thumbs-down button below the menu bar or selecting it from the Windows menu. Open it, and take a look.

Click on the Evaluation window button.

The Tuttle family in Dover, New Hampshire has continuously worked their 245-acre farm since 1632, making it the oldest family farm in America. The land has always passed intact to the last-born son.

Courtesy of Old Farmer's Almanac

You can see a measure of your farm's growth, the town's growth, crop productivity, and other factors that let you know how your farm is doing. These are all measured in comparison to the previous year. Red bars indicate a negative change (lower than last year), green bars a positive change (higher than last year). No bar indicates that there is no significant change from the past year.

At the bottom of the Evaluation window are boxes that display icons to point out current problems, and to suggest what you should plant for a healthy crop rotation. These icons are real-time indications of present field conditions, and change quickly. You'll want to refer to this window occasionally for a push in the right direction.

Close the Evaluation window.

SPRAY IT, DON'T SAY IT

Since you've just had a harvest, this might be a good time to return some nutrients to the field.

Click and hold on the SPRAY button to open a submenu.

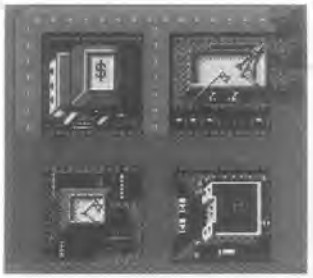
Select FERTILIZE.

Click on your field.

Your tractor, with a sprayer attached, will roll around your field. Repeat the process on your own, but this time spray some fungicide—wouldn't want any wretched fungi ruining our day, would we?

After spraying the fungicide, you might see old Toxic Tommy (the skull and crossbones) appear on your field. His presence informs you that toxins are present on the land, and reminds you that these chemical additives, while very useful, are dangerous if overused. They can be a boon to your crops if properly managed, but they can also wreak havoc on fertility and land value. Use them with caution. (SimFarm doesn't consider fertilizer to be a toxin.)

A SENSE OF COMMUNITY



It may be a surprise to see how many of your decisions affect your community. You should periodically check the state of things over in the little town: it can be a lively place. The community will thrive as you thrive, and your successes will be reflected in expanding community growth and the upgrading of community property.

Your timely buying and selling (and increased tax payments) will cause those trailer-park and Quonset-hut homes with the black-and-white TVs to be replaced by those snappy little numbers with the pruned rows of shrubbery. Eventually, the community will purchase new plots of land to accommodate the mushrooming population. Also, you will occasionally get to vote—by means of a dialog window—on the type of town development that you're interested in, though your vote isn't always on the winning side. If you do get the chance to cast your ballot, put your two cents on the airport expansion, and you'll be able to buy your own crop duster and fly it around.

Residential
Commercial
Airport
Recreational
The town is purchasing a new plot of land. The mayor is asking voters to vote on what kind of plot should be built. Click on your preference for what kind of plot the town should build.

Almost all of the ginseng grown in the U.S. is grown in Wisconsin. Research suggests that properties of its roots can loosen joints stiffened by age and improve athletic performance. However, the performance *usually* associated with ginseng use is the enhancement of sexual prowess. As one saying goes, it "makes an older woman younger and a younger woman hunger."

Courtesy of Old Farmer's Almanac

OUT OF THE RED AND INTO THE BLACK

While the town may by mushrooming, your Funds probably aren't. Initial purchasing and leasing at the start of a game can put you in the hole, and you'll need several rounds of harvest and livestock sales to get out of the red. Let's take a look at the Balance Sheet to see how your farm finances are faring.

Click on the Balance Sheet button below the menu bar.

The Balance Sheet is a detailed breakdown of your profits and losses, grouped by Assets, Expenditures and Revenue. Within those headings are the present values for all your land, equipment and livestock holdings; income from the sales of any of these items; and expenditures for all purchases, including loans and taxes. Your total expenses and the profit/loss figure are at the bottom-right of the window. The bottom-left has an estimated yearly tax figure that will change according to how your farm changes. There's also a line for your quarterly loan payment.

Messages will appear to inform you if your funds are dwindling to emergency levels, and give you the opportunity to rectify things. If you don't heed their call, the simulation will rudely start selling off your assets. You'll lose the game if you go bankrupt, so stay alert. On the other hand, if your funds are doing well, you'll be visually rewarded with the antics of Cowman Mooranda. (You'll know when it happens.)

This window might put a damper on the sunshine of your situation, but hey (hay?), we didn't say it was going to be easy. Besides, you've barely got your thumbs dirty enough to see if they're really green or not.

Close the Balance Sheet window.

Note: While we're touring around looking through windows, you should occasionally check in on your livestock. They're probably hungry or thirsty (or dead) by now.

CREDIT WHERE IT'S DUE

Time to do what Americans in financial trouble have done for generations: borrow.

Click on the Bank window button below the menu bar.

The Bank window will open, giving you a display like that on your friendly ATM machine. Your available cash, current debts, credit limit and current loan interest rate are revealed to you. Your credit limit is based upon your assets, including improvements (roads, structures, etc.) made to your property. The interest rate will shift throughout the game. Let's borrow $1,000 for starters.

Click on the number keys to punch in 1000.

Click on OK.

Your quarterly loan payment will appear under the interest rate figure. The bank will automatically deduct (every three months) your loan payments, or you can pay the loan back in full at any time by clicking on the REPAY button.

Close the Bank window.

A narrow shelf of land between Santa Barbara and Ventura in California is home to the U.S.' only banana plantation, where 40 different types of the tropical fruit are harvested. Some varieties taste like peaches, some like raspberries, and one, the Popoulu, is the size and shape of a baseball.

Courtesy of Old Farmer's Almanac

I SPY

You may sometimes need to explore your farm and get instant appraisals of every item you own. You can do this in the Edit window by clicking on the Magnifying Glass (Examine) button and then clicking and holding on any item, be it equipment, machine or animal.

Click on the Magnifying Glass button.

Click on an item that you own.

A window will pop up that reveals the item's condition and age, or depending on what it is, some other variables about its status.

Go ahead, be nosy. Wander around the Edit window and examine everything you see. If your farm's going gangbusters, you might even see your house upgrade to the higher-priced spread.

DOUBLE YOUR PLEASURE

So far, we've only dealt with a single field of tilled earth. Hold on to your straw hat farmer, 'cause we're going to up the ante a little bit by putting down another field and setting up the simultaneous planting and harvesting of both of your fields using the grandiose powers of the Schedule window.

Select a site for your new field close enough to your original field so you can oversee the work on both of them without having to scroll very much. After selecting your site, plant a field with the crop of your choice, then add dirt roads, both to the old field and around the circumference of the new—leave room for an irrigation ditch if possible.

Click and hold on the PLANT button in the toolbar, select a crop and place the field. Add dirt roads, as needed.

Every good farmer knows that too much wind will cause topsoil damage, so next, we'll place trees around the perimeters of your fields to act as windbreaks. For windbreaks to be effective, they must be no more than two tiles away from the field they protect, so place them just outside the dirt roads. While you're at it, put a few trees in the cow pen and they'll have it made in the shade.

Click on the Trees button in the Edit window toolbar.

Surround your fields with trees, just outside the dirt roads.

One can determine the outside temperature in Fahrenheit by counting the number of chirps a cricket makes in 15 seconds and adding 37.
Courtesy of Old Farmer's Almanac

A TIGHT SCHEDULE (WINDOW)

You now know all the basics of running SimFarm. In fact, you know enough to keep a small farm running for generations. But once your farm grows, and you have a number of different fields growing at once, things will start to happen fast and furiously. Keeping track of multiple plantings and harvests can get confusing, and lead to waste. That's where the Schedule window comes in.

At this point in the tutorial, we'll just take a quick look at the Schedule window and let it go at that. When you've had some time to use your new knowledge and have built your farm up a bit, you'll be able to come back and really appreciate this window.

Click on the Magnifying Glass button in the Edit window.

Click on one of your fields.

The Schedule window grants you extraordinary powers of farm management: here you have the ability to set "timers" to plant, spray, harvest, and then begin the cycle over again, well into the future.

The Schedule window also has gauges that display readings for the presence of Crop Disease, Pests, Weeds, Water and the Soil Quality in the field. One last thing you can do in the Schedule window is to sell your crops in the futures market. You can make a lot of money in futures—and lose a lot.

When you're ready to automate your farming tasks, see the Reference section of this manual for everything you could ever want to know about the Schedule window. The Reference section also has a lot of information on every SimFarm feature, function and window, details on crops and livestock, plus strategies to make your farm more successful.

SIM Farm

SO LONG, IT'S BEEN GOOD TO GROW YA

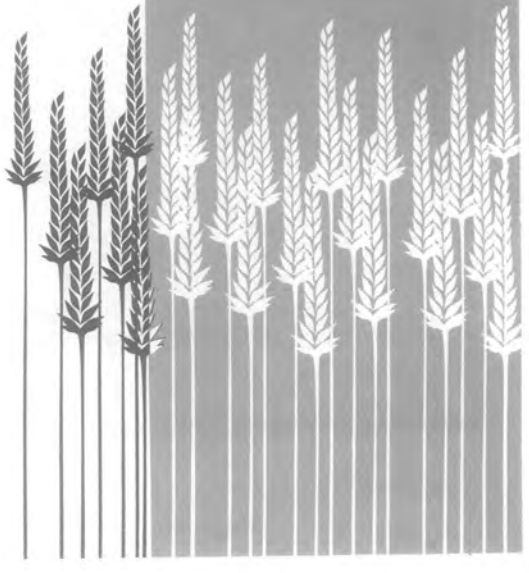
Well, you've slogged your way through this tutorial, and you can probably tell the difference between apple pies and cow pies. Time to dig the dirt and get to work—but then again, there's fun, too. There are eight scenario challenges—different farms in different lands in different levels of development—for you to take over and turn into profitable agricultural ventures. And, once the town gets big enough, and gets an airport, you can buy your own crop duster and fly it around, dusting your crops and buzzing your cattle.

Make sure you've got a spare pair of overalls and plenty of gas for the tractor—there's work to do, bub!

For an environmentally safe pesticide, prepare an infusion of cigarette or cigar butts (no filters), onion skins, and marigold blossoms. Simmer in water for an hour, strain, and spray freely on flower, fruit and vegetable plants. Will repel airborne insects as well as beetles and slugs.

Courtesy of Old Farmer's Almanac

REFERENCE



Worm or beetle—drought or tempest
on a farmer's land may fall,
each is loaded full of ruin,
but a mortgage beats 'em all.

— William Carleton

SIM Farm

REFERENCE

This Reference section provides SimFarmers with a point-by-point profile of the game, broken down by its various menus, windows and commands. There is also a Strategies chapter at the end of this section.

Give yourself a head start by playing through the Tutorial to familiarize yourself with the game before you delve deeply into the nuts and bolts of this section.

THE BASICS

Here's a brief overview of the basic elements of SimFarm that you will be dealing with during the course of the game.

TILES

Objects in the game occupy spaces that we will call "tiles." For example, a tractor takes up one tile; fields are an 8X8-tile square. The entire SimFarm world is a 96X96 tiles square.

LAND

The SimFarm world is divided by a grid pattern into a 12X12 square of land plots, 144 in all. The grid is visible only in the Property map in the Map window. In each scenario or game, some of the plots will be yours, some will belong to the local town and the rest will be up for grabs. You can only build or plant on your own land.

Your land is surrounded by a fence. When you buy more land, a fence will automatically be built around it. Purchase prices for land are based on soil quality (including how rocky it is), groundwater, and toxicity. Land with good soil quality and plenty of water will be quite a bit pricier. You can also sell your land, though it must be clear of all roads, fields and structures. Its price depends on the same factors as land you purchase. The plot of land that holds your homestead cannot be sold.

YOUR HOMESTEAD

You are provided with a homestead at the outset of each game. The appearance of your homestead changes, reflecting your abilities as a farmer and your level of "prosperity." You'll get some lovely additions to your home if you're in the money; if not, you can always keep the shades drawn.

BASIC HOMESTEAD

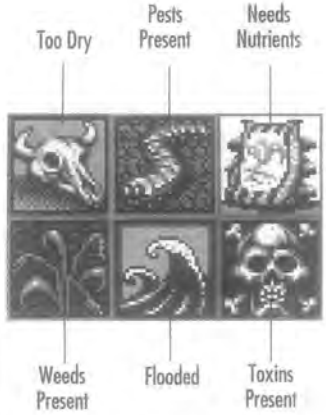
UPGRADED FARMHOUSE

FIELDS

Fields are the lands reserved for planting crops. All fields are an 8X8-tile square. They must be placed on cleared land, somewhere within your fence line. After you place a field, its appearance reflects the current activity: you'll see rows being planted, crops will grow and change color, and harvested fields will be "emptied."

You can view overall soil conditions in the Map window and specific field readings in the Schedule window (see the Windows chapter). Fields can be bulldozed if they become overridden with toxins or pests; you'll see a snappy "flameout" animation when you send them eternity's way.

The quality of your fields and their output is affected by soil quality, the weather, harvested crops, chemical additives and disasters. Information icons will appear in your fields to notify you of soil changes.



SOIL CONDITION ICONS

PLOWING AND PLANTING

One game week after field placement, your field will be automatically plowed and planted. If you haven't purchased the tractor, plow, and planter beforehand, they will be leased to you, with the leasing charges (a pocket-draining percentage of the machine's purchase price—*per use)* subtracted from your Funds after the operations are completed.

The amount of seed required for one planting of a field is fixed, a single unit or "bag." Seed can be purchased in advance in the Buy window, or automatically purchased as necessary by selecting AutoBuy (the game default) in the Options menu and then planting a field. Seed selection after field placement (for crop rotation) can be made in the Schedule window (see the Windows chapter).

There are 24 different crops included with the game; up to 16 can be loaded into the game and grown at a time. Crop characteristics—how fast they grow, what they require in rain and temperature, etc.—are different for each crop, and are affected by weather and soil conditions, as well as disasters. Information on and advice for growing each of the crops can be viewed in the Farm Expert window.

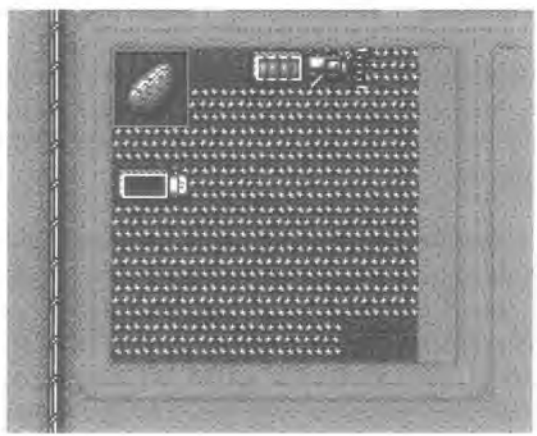
If the goose honks high, fair weather; if the goose honks low, foul weather. Fish bite best just before it rains.

Courtesy of Old Farmer's Almanac

HARVESTING

Harvests depend on the individual crop and game specifics. At harvest time, fields are very active with moving trucks, chopped crops, and sometimes busy workers. Required harvest machinery includes a harvester, a truck and a trailer, either leased or owned. The truck will appear "full" after harvest. The harvested crop will either be stored in silos (if you have any), or immediately sold at the current market price.

Every crop has an optimum storage temperature; for every week the crop is stored above this temperature, its value drops.



MARKET VALUES

Market Values are the optimum price you can get for each crop—what the highest grade of a particular crop harvest would sell for at that specific time. Values fluctuate considerably over time according to weather, time of year, disasters, etc.

The actual income you receive from your harvest is a percentage of the current market value of the crop, based on your crop's quality, which in turn is based on the current weather, sunlight, water and soil conditions.

SIM Farm

LIVESTOCK

The four types of livestock in SimFarm—cows, pigs, sheep and horses—can be raised and sold like crops. If they aren't fenced in, they'll roam about, eat your planted crops, and cause general mayhem. Each type of stock has common characteristics of behavior, growth, food intake, and resistance to injury; you must monitor their needs carefully. You can breed them for increased income. With care, their sale value will steadily rise, but poor maintenance and old age will bring the beasts—and your profits—crashing down.

WEATHER

When you select a farm site from the map of the U.S., its weather patterns will correspond with the actual patterns for that area.

Weather in SimFarm includes rain, temperature, and wind speed. There are five types of days—Sunny, Partly Cloudy, Cloudy, Raining and Snowing. Each type of day has a different rate of evaporation.

Wind speed directly affects the soil quality of fields by blowing away valuable topsoil, necessitating fertilizer applications. If high winds are not dealt with by placing windbreaks, crops and fields will lose value. (Windbreaks within two tiles of a field offer protection.) High winds also speed evaporation, and combined with high temperatures, can result in groundwater loss and threats to harvests (as well as threats to your hairdos). Groundwater in SimFarm has 12 stages of "wetness," from desert-like to extremely moist, changing according to weekly temperatures and rainfall totals.

Don't look to the skies for answers, just for weather.

MONEY

You begin each game with a specified amount of cash ($40,000 for non-scenario games). Money is automatically added or deducted after game actions. When harvests are sold, their value is credited to your funds. Charges for leased equipment are directly subtracted from your funds upon use, and loan payments are deducted quarterly. Taxes on income and assets are deducted at the end of each calendar year.

The program will inform you if you cannot pay for purchases, loans or leases, and will provide you opportunities to sell assets or borrow money—or do it automatically if you resist. All of your financial aspects and holdings can be viewed in the Balance Sheet window. If you do reach the point where it's only you and your homestead, the Tax Board or the Bank will come and confiscate your few bare, grubby acres—aren't you glad it's only a game?

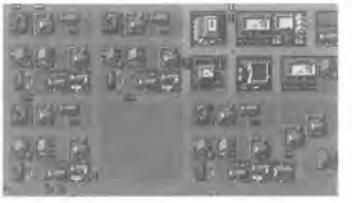
THE TOWN

If the town is booming, so are you. Town expansion depends on your tax payments and some other farm development factors. The community will expand, a plot at a time, in any direction from its starting point. You cannot purchase town property, though the community has the option of selling its land if your growth slows or halts entirely. The town will grow and change depending on your prosperity. Those town buildings representing community

(and game) institutions, such as the local bank, can be clicked to open their respective game windows.

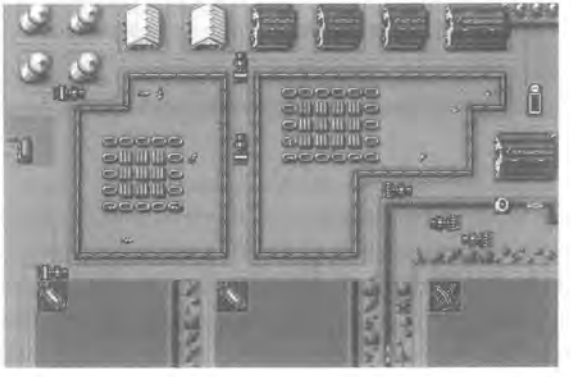
When the town is acquiring more land, you'll be given a message window that allows you to vote for what type of development will occur, though your vote doesn't always carry the campaign. (Not only is lunch not free, sometimes it even tastes bad.)

Residential
Commercial
Airport
Recreational
The town is purchasing a new plot of land. The mayor is asking voters to vote on what kind of plot should be built. Click on your preference for what kind of plot the town should build.



SCENARIOS AND GAMES

You can begin a farm in SimFarm in three ways. You can choose any of eight preset scenarios, each of which provides a different farming challenge with a different-sized farm, town and bank account. You can click on a region of the U.S. and start a brand new farm with the land and weather conditions of that region. You can design your own terrain upon which to begin your new farm.



DISASTERS

If you don't find that maintaining all of your fields, machinery, livestock and finances are challenge enough, why not throw in a disaster or two? These disasters are guaranteed to put some furrows in your brow as well as your fields.

Disasters can partially or completely destroy a field, and thus your field profits. However, the next plowing and planting will restore that good earth. Disasters can also take out portions or the entirety of the town, but it will refresh fairly quickly. You can even choose multiple disasters, if you like your problems in pairs. Disasters are sometimes brief, sometimes not, and they will not always directly affect your farm, though through their effect on the surrounding community, there could be many indirect effects.

There will be a message window on-screen to alert you of the presence of a disaster and when the disaster has passed. You can disable disasters if you prefer not to deal with them.

To prevent blisters from hand tools, wax the handles with paraffin or an old candle before using. The wax gives a solid grip and stops the turning motion of the handle, which causes the blisters.

Courtesy of Old Farmer's Almanac

MENUS

The menu bar at the top of the screen contains pull-down menu commands for various game functions. All of the menu commands are activated by clicking and holding on the menu name with your mouse and then sliding the cursor to the item of your choice, which will highlight. Releasing the mouse button executes the command.

Below the menu bar is the Control bar with buttons to quickly open windows.

FILE MENU

The File menu contains the system-related commands for SimFarm.

ABOUT SIMFARM reveals critical information about the creative sorcerers that produced SimFarm and also tells you the whereabouts of all of your missing socks. On the Macintosh, ABOUT SIMFARM will be under the Apple menu.

NEW GAME brings up the Select A Region window, where you can either pick a fresh farm landscape upon which to focus your fertilities, or design your own. If you choose New Game while running another farm, you'll be prompted to save your current game first.

SAVE stores your current game to disk under its current name and in the same disk location. The first time you save a game—before it has a name—a dialog box will open, letting you name the game. If you want to change an existing game's name or disk location, select SAVE AS....

SAVE AS... opens a dialog box allowing you to change an existing game's name and/or disk location. For details on saving games on your computer see your machine-specific Addendum.

LOAD GAME brings up a dialog box that lets you choose and load a game that has previously been saved to disk. For details on loading games on your computer see your machine-specific Addendum.

LOAD CROP opens the Load Crop window, which allows you to choose and change the crops that are available in the game. There are 24 total crops, 16 of which can be active at a time. You can change crops during a game, but you can't replace a crop that is currently growing or has been harvested and is stored in a silo, or if you own seeds from that crop.

QUIT closes down your farm and returns you the world of bad TV and laundry.

OPTIONS MENU

The Options menu lets you customize a number of gameplay settings. Selected (active) options will have a check mark next to them.

MUSIC toggles the musical soundtrack (consisting of several different tunes) on and off, giving you nice melodies for enticing crop growth (you know what they said about house plants and Chopin) or only the music of your mind as you calculate profits. Sound quality varies according to your computer's sound card or lack thereof.

SOUND EFFECTS toggles on and off the sound effects of you and your farm at work. I wouldn't blame you if you planted trees just to hear 'em bulldozed, but don't tell the Sierra Club. Sound quality varies according to your computer's sound card or lack thereof. Sound effects may not play at all if you don't have a sound card.

AUTOBUY (the default) automatically buys seeds for you as you plant, relieving you of doing it manually—whether you plant through the Schedule window or through the Plant button in the Edit window. You will get a message telling you that seed isn't available if you try to plant without either purchasing seed or without having AUTOBUY selected. The purchase price will vary with each type of seed. Having AUTOBUY selected also takes care of the purchase of any chemical additives. However, all purchases using AutoBuy will be more expensive than if you buy the goods on your own and store them.

AUTOSCROLL (the default when present, but not available on all computers) causes the terrain to scroll when you bring your mouse pointer to any of the screen borders. The terrain scrolls towards the edge of the pointer's contact, and stops when you move the pointer away from the edge.

AUTODOZE, if on, automatically clears terrain of obstacles when you place a field or structure, so that you don't have to labor manually. You will be charged for the bulldozed objects just as though they were manually removed.

AUTOGOTO, if selected, zips the game terrain to the site of vital game events, such as disasters, so that you can utilize all of your considerable farming know-how to deal with the emergency. Or you can deal a hand of solitaire while you watch the locusts devour your tomatoes.

MESSAGES, if selected, will display all of the message windows that warn you of impending weather perils, community events and general conditions. If deselected, only information of pressing significance to your farm's operation is displayed. You can hit Return or click on OK to remove messages from your screen.

AUTOLEASE will automatically lease equipment necessary for farm operations. The fee for leasing (a heavy percentage of the purchase price *per use* of the leased equipment) will be immediately deducted out of your funds after the operation is performed. The simulation will inform you if AutoLease is unselected (default is on) and you haven't the equipment for scheduled events. If you do choose to lease a lot of your equipment, you will be charged less for leased equipment damage if you construct a road from your farm to the town (bulldoze a section of your fence for entry), so that the machinery has smoother access.

SPEED MENU

The Speed menu lets you decide whether your crops will grow like this country's deficit (that's *fast,* for those of you who haven't renewed your newspaper subscriptions) or else just kinda mosey along. The actual speed of game operations will vary according to your computer's clock speed.

ULTRA whips through time like a Las Vegas blackjack dealer, so that you can't see much of the growth phases of the crops; use it only when you want to bound into the future with seven-league boots.

FAST is a good setting if you need to hurry a harvest or get through a wet winter.

NORMAL is for those who don't want to tamper with Mother Nature.

SLOW lets that syrup drip at its own pace out of your maple trees.

PAUSE will freeze gameplay, giving you an opportunity to contemplate executive farm decisions.

When planting pepper plants, put a matchbook (without covers and staple) in the bottom of the planting hole. This encourages stonger, healthier plants.

Courtesy of Old Farmer's Almanac

WINDOWS MENU

The Windows menu contains a list of choices that open the various windows. They are toggled on or off by selecting them with your mouse. Active windows will have a check mark to the left of their names in the menu.

BUY opens the Buy window, where you can purchase seeds, equipment and other farm necessities.

SELL opens the Sell window, where your can peddle your harvested crops, aging equipment, and fatted calves on the open market.

EVALUATION brings up the Evaluation window, presenting you with a picture of the development of your farm and the community over the past year, and giving you field assessments and suggestions.

MAP opens the Map window, where you see the SimFarm world in miniature. Make your land deals here and check on a range of soil evaluations and readings.

WEATHER displays the Weather window, where all of the pertinent climatic facts now and in days to come are yours for the viewing.

BALANCE SHEET gives you the fiscal lowdown (and we hope, the highups) on your Assets, Revenues and Expenditures, so you can see the arrival and departure of your money in detail.

BANK brings up the Bank window, where you can take out and pay loans, and see your bank records.

EDIT is the main view of the SimFarm universe, the big picture where you make it all happen.

MARKET VALUE is the window that displays the current prices for a perfect harvest of every available crop, and a 30-week value-trend chart.

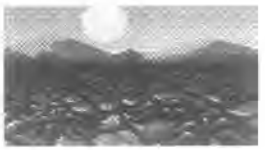
FARM EXPERT displays the Farm Expert window, where you can obtain information and advice on machinery, buildings, crops, livestock, and sprays.

DISASTERS MENU

The Disasters menu tips its cap to SimCity, another fine Maxis product that implements these intriguing means to really mess up your day. You can choose the Disable command if you can't weather that much weather. Disable will not stop a disaster in progress, but it will put a halt to all subsequent disasters.

TORNADO gives you a twirling twister that will sweep a path of random destruction through your fields and the community in general—or it might miss all the developed areas. You'll get a fearsome message window alerting you to its presence. You can locate the tornado by clicking in the Map window, where a "D" (for Disaster, the locator for Tornadoes and Locusts) marks its malignant presence. If it's ripping in your direction, windbreaks won't be any relief—you could try an instant harvest of all fields from the Schedule window. If it gets to your fields, you might want to go visit Aunt Mavis in Pocatello: there probably won't be much left to harvest.

LOCUSTS can give your farm that unique Biblical aspect, though you might tire of playing Job. These creatures are here in number, and they're HUNGRY! They could gobble all of your goods, so this could be a good time to cancel any plantings, and perhaps do some field maintenance or some chemical additions if necessary. Sometimes they'll just swarm in one spot, other times they'll seek and destroy. Go figure.



DROUGHT dries up your crops, stored harvests, seeds, and eventually your cash if you aren't careful. You'll have to make strategic use of lakes and rivers and ditches and pumps to manage water sources, and make sure your plantings are for crops that aren't water-intensive. Particularly severe droughts may reduce big rivers to a trickle, so you might have to let lands lie fallow to cut your losses.

FLOOD washes the land in excess wetness, causing rivers and lakes to surge and break their banks. You might be able to drain water off your fields by surrounding them with water ditches and making sure any valves and pumps are turned off. This might be a good time to plant rice, which is a crop that likes a good soaking. Floods make any pumps you've placed in rivers or lakes stop working, and will sometimes destroy them. If the town is still small, and a flood occurs close by, it can be severely damaged. (And I'll say this in a whisper: so can your farm, so think twice about buying land *too* close to water.)

FROST sends the chilly teeth of winter biting at your neck. Harvests can be totally destroyed or of very poor quality and yield. Look for cold-weather crops, or let the fields lie fallow.

WINDSTORMS make the winds blow like an inflated politician, so put a deep line of windbreaks around your fields to protect your precious topsoil. Unprotected soil will diminish in quality (and value) over time after a number of windstorms. You can chart the decline in land value over time due to windstorms in the Map Property window.

DISABLE prevents disasters from occurring. If you choose Disable while a disaster is in progress, it will not stop it, but it will put a halt to all subsequent disasters.

S. J. Perelman called farms, "an irregular patch of nettles, bound by short-term notes, containing a fool and his wife who didn't know enough to stay in the city."
Courtesy of Old Farmer's Almanac

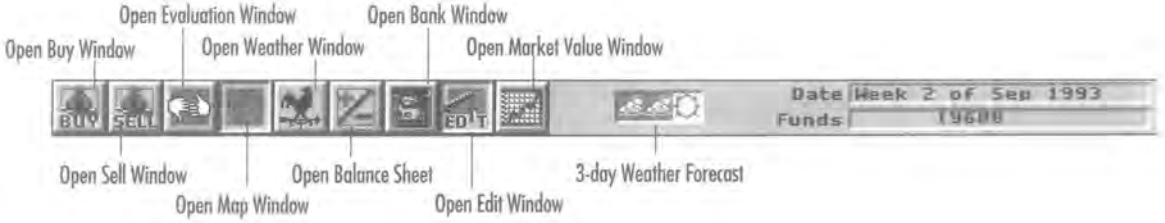
WINDOWS

SimFarm's windows are where you'll do the dirty work—you can get your tools, put 'em in action, and see the results from a variety of angles through all of the window views of the SimFarm world.

Windows can sometimes be concealed or overlapped by other windows, but they will remain open. The window buttons below the Windows menu will be depressed when their associated windows are open. Windows can be moved around on-screen by clicking, holding and dragging with the mouse pointer on their title bars. They can be closed by clicking in their close box in the upper-left corner of the window, or by clicking on the CLOSE button.

CONTROL BAR

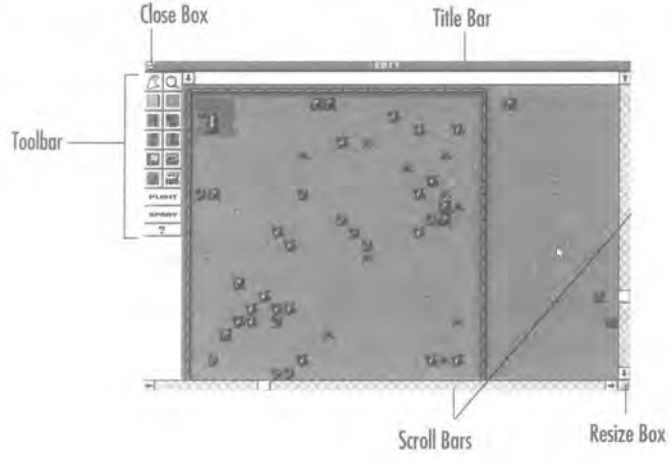
Just below the menu bar is the Control bar. It has buttons to easily open most of SimFarm's windows, provides a short-term weather report, and displays the Date and your current Funds.

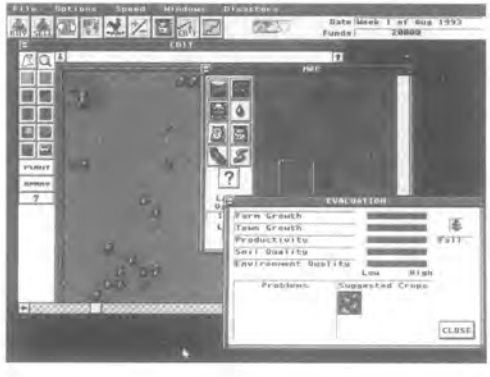


When a window is open, its corresponding Control bar button will be depressed. (Don't worry—it can get counseling.)

EDIT WINDOW

The Edit window is your principal area of business, the level at which you implement most of your farming decisions and see their consequences. From this window, all of the game commands in the menu bar and the toolbar are accessible. Other command windows can be opened on top of the Edit window, and most of their functions will operate while your farm is active in the background.

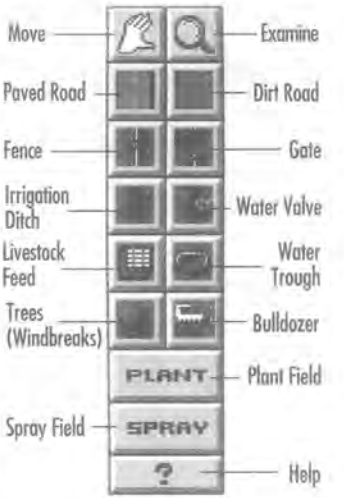




You can use the scroll bars and arrows to move around the SimFarm world. Or, if your computer supports AutoScroll, just move the cursor to any of your screen's edges and the terrain will scroll in that direction. You can also shrink the Edit window to more easily use other (possibly obscured) windows by clicking and dragging the size box at the bottom-right corner of the screen to shrink it. If you leave an exposed edge of a window underneath other windows, clicking on the bottom window will bring it up over the top-layer window. Active windows have highlighted title bars.

TOOLBAR

The toolbar is the vertical row of buttons along the left side of the Edit window. When clicked, the buttons provide you with a number of construction and field functions in SimFarm. The buttons will appear depressed when active, and their functions and costs appear in the message and title bars.



MOVE

The button with the little hand on it is the Move button, which when clicked turns your cursor into a little set of open-handed "pinchers." You will then see a message in the message bar that says, "Choose an object to move." Clicking on any of the farm machinery in the game will close the hand and the message will read, "Choose a destination." Wherever you next click the mouse will be the destination point for your machinery. If it is a self-propelled item like a tractor or truck, it will move on its own, and if it is an item like a planter or trailer, your tractor or a leased tractor will come and move it for you. You can also move feed and water troughs if you have placed them awkwardly.

This command is useful for storing machinery in sheds to protect it from deterioration when it's not being heavily used, and also to move certain pieces of equipment near fields that need them. The simulation chooses the equipment nearest a field for whatever action the field demands, so specific equipment can be moved to designated fields, hastening its implementation and saving driving wear and tear from searching for roads. Equipment exposed to the weather loses its value faster than when it's stored, so give your machines a roof if possible.

You can also use the hand cursor to "herd" your livestock—you can corner them against a fence or block their forward movement by putting the Move cursor in their path.

Move

MAGNIFYING GLASS (EXAMINE)

The Magnifying Glass button changes the cursor into a magnifying glass and provides an information readout on whatever game terrain or object on that terrain you click it on. Clicking and holding the mouse on farm equipment gives you the valuation information you would find for it in the Sell window, and sometimes info about its operating status. This can be very practical data, since the value of the machinery declines with damage and age; thus, you might want to sell some equipment before you can't get any return on it at all, or you might also want to restrict the use of some equipment so that it doesn't sustain any more damage. Livestock values work much the same way, and you can also see if your livestock are pregnant. Clicking on a field opens the Schedule window for assessments of that field's soil and water quality, pests, weeds, and disease, as well as for setting the field's planting schedule.

PAVED ROAD

The Paved Road command will lay road tiles after selection when the mouse button is clicked, held and then dragged across the terrain surface. Roads will zig and zag with your mouse movements. Farm machinery will "seek" roads in the quest to move most efficiently across the terrain, so lay them to maximize access to your fields and structures. Roads cannot be laid over fields, structures, machinery, terrain elements or your homestead—only on bare land or on dirt roads. If you place a road over a water ditch, a bridge will be constructed automatically. It costs $30 to lay one tile of paved road.

DIRT ROAD

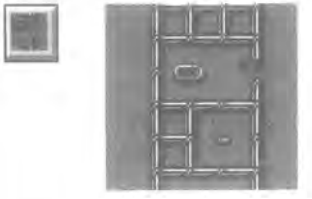
Dirt roads are placed just like paved roads, but fields, structures and construction tools like windbreaks can be placed upon them—the simulation treats them like bare land. They are cheaper than paved roads, and make a good choice for travel within your property boundaries. Dirt roads damage your equipment slightly more than paved. Dirt roads cost $20 per tile.

FENCE

Use the Fence button to enclose your livestock, preventing them from gobbling your crops and becoming roadkill. You place fences much like roads; your corrals can take on extravagant shapes if you wish: perhaps the outline of your initials, like the brand on your cattle. Hungry or peevish livestock can damage fences and escape. Fences cost $50 per tile.

GATE

You can put gates in your corrals and on the fences on your property line. Gates are placed by clicking; clicking with the right mouse button (Option-click for Mac) will toggle the gate open and closed. Machinery can pass through closed gates, but animals cannot. Gates cost $75 each.



IRRIGATION DITCH

The Irrigation Ditch button lets you place ditches to direct water flow from your source, which can be a lake, river or windmill you have purchased. Ditches can be placed directly below or next to windmills to obtain water. Water always flows away from the source and can be greatly aided in its delivery with the purchase and placement of a water pump. A pump is mandatory to obtain water from a lake or river, and can be placed right on the river or lake's watery edge. Putting a valve on your pumped water gives you a chance also to use the ditches for drainage: when your fields flood, turn the valve off so that the ditches are dry, and they will drain water from the field. This is most effective when the ditches run the full length of the field. (Note: you cannot fill your swimming pool from a water ditch.) If you try to place a ditch over a road, or vice versa, a bridge will appear. Irrigation ditches cost $35 per tile.

WATER VALVE

Water valves control the flow of water through your irrigation ditches. When placed on top of or within one tile of a ditch, water movement can be started or stopped by clicking with the right mouse button (Option-click for Mac) on the valve, changing its

color from green (flow) to red (stop flow). You should stop water flow to fields when you see the wave (flooded) icon, which often appears after a period of rain. The cow skull indicates very dry fields. Check your crop data in the Farm Expert window for water needs of specific crops. Water valves cost $80 each.

LIVESTOCK FEED

The button with the little hay bale is generic animal feed for your livestock. Feed should be placed within corrals that all of the animals can access. You will see feed diminish, and your animals grow after they nibble from it. The simulation will alert you when food levels are low or if your livestock have difficulty reaching the food. Keep a keen eye on animal maintenance; their value can decline quickly with age or if you don't keep 'em fat and sassy. They can also get a mite rambunctious if they're hungry. One unit of feed costs $100.

WATER TROUGH

Water is a significant farm commodity, both for crops and animals. Water troughs must be placed much like the feed units, easily accessible and vigilantly maintained (you can move feed and troughs with the Move command). When placed, you will see them as a brimming blue, but if they go gray, they (and your animals) are all dried up. The simulation will warn you of thirsty beasts, but don't let that go on too long—their health and value will be adversely affected. You can keep a water trough full for a long time by purchasing a water tower in the Buy window and placing it on your property. The tower will need a full water ditch nearby to keep the troughs full. Water troughs cost $15 each.

TREES (WINDBREAKS)

The Tree button gives you the chance to place trees on your farm to protect crops from the wind and to green things up a bit. You must place at least eight tiles of trees within two tiles of a field to make an effective windbreak. The trees do add a painterly touch to it all as well. Trees cost $10 each.

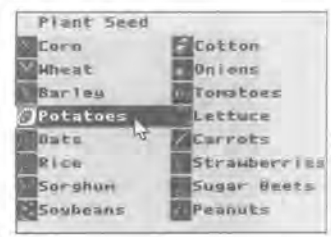
BULLDOZER

The bulldozer lets you clear land of rocks and debris, and remove or destroy fences, fields and equipment. (We don't call this SimCity's Country Cousin for nothin'. You'll recognize the look and function of the bulldozer as similar to that of its famous relative.) If you have AutoDoze selected in the Options menu, you can place fields and equipment over other objects without bulldozing first. Otherwise, you'll have to bulldoze and clear the land before placing anything. You'll get a dialog box from the simulation asking if you are sure you want to send significant objects to kingdom come.

Some fields may become so tainted by toxins that they can't be rescued; the only humane thing to do is 'doze them. Field bulldozing is a bit of a spectator sport, as you'll see. Bulldozing an object costs $25 per tile, whether done automatically or manually.

PLANT

The big button that says PLANT is the command to really get things rolling—and growing—on your farm. Click and hold on this button and you will see a list of all of the available seeds in the game, with pictures of their associated crops. Move the mouse pointer to highlight the crop you want, and when you release it, the pointer becomes the outline of a field, which is placed where you next click. Fields must be placed on bare land; you can clear land with the bulldozer if there are rocks or trees in the way. You'll get a "Cannot place field there" message if there's a problem. Immediately after placing, the field will be plowed and planted with the selected seed. Planting costs $120.



If you haven't previously purchased seed, you'll be charged for it out of your funds. Having AutoBuy (the game default) selected in the Options menu will automatically purchase the planted seed for future plantings, as seen in the Schedule window timeline. If AutoBuy is off, you'll get a message window suggesting a seed purchase. You can replace the available seeds at any time in the game with other choices by using the Load Crop command under the File menu.

Fields themselves can be bulldozed if they have become overwhelmed with pests, if they are too toxic, or if their placement has become unsuitable. You cannot sell land that has fields or equipment on it. You should surround your fields with access roads to ease the strain on your machinery and enable easy approach for leased machines.

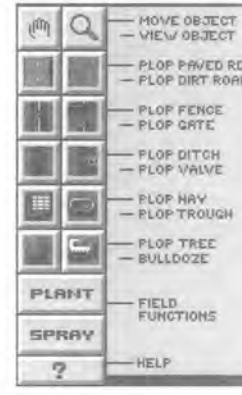
Icons indicating the presence of toxins, pests, disease and high or low moisture content (skull and crossbones, centipede, decayed corn and breaking wave and cow skull, respectively) will periodically appear in your fields and can indicate crop problems. Refer to the Map window for overviews of field quality throughout the territory; you can also get individual field specifics by clicking on the Magnifying Glass and then clicking on the field, which brings up the Schedule window's field-reading gauges. Long-term field damage will cause a decline in land value.

SPRAY

Clicking and holding on the SPRAY button opens a submenu with your spray choices: Fertilizer, Pesticide, Herbicide, and Fungicide. Highlight any of those with your pointer and then click in the field where you want to place the additives. Your machinery or leased machinery will then spray the field with your selection. You can also arrange sprayings through the Schedule window, using the drag-and-drop icons on the timeline. Use a subtle hand with the chemicals: there will be times when you must use them for pest infestations and nutrient loss, but heavy-handedness with them over the long haul will tax your field quality and yields, and eventually affect land values. Use the Schedule and Map windows to obtain info on chemical levels in the soil. It costs $200 to spray a field; the AutoBuy option will automatically deduct the cost from your funds.

HELP

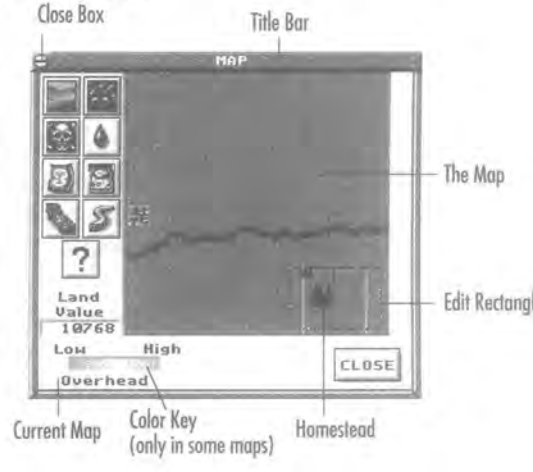
Below the SPRAY button is a button with a question mark on it. If you click and hold on it, all your questions will be answered—well, at least the ones about toolbar functions. You'll see an information window that reminds you of what each of the toolbar buttons does.



MAP WINDOW

The Map window gives you a consolidated view of the entire SimFarm world, displaying your land, the town's land, and all of the lands available for purchase and development. The Map window opens on top of the Edit window at game startup.

The window's default Overhead view gives a rough sense of terrain and development, miniaturizing buildings, rivers, etc. The rectangle within the territory captures the land displayed in normal view in the Edit window. You can gallop swiftly across the land by clicking anywhere in the Map window, and the rectangle will follow, moving the Edit terrain along with it. You can also click and drag the rectangle for more precise alignment.



Along the left side of the Map window are two rows of buttons. Clicking on them lets you select different map displays with information critical to decision-making about your current and future properties. Clicking on the button again toggles back to the Overhead view.

The name of the active map appears at the bottom-left corner of the window. When appropriate, a color key to help you interpret each map will appear above the map's name.

You can gain a tremendous amount of information from these maps. Be sure to periodically use them to check field conditions, which can change from harvest to harvest. Besides their usefulness in land sale/purchase decisions, keeping a steady hand on when to add or not to add fertilizers and chemicals to your fields can improve your harvests and boost your Prosperity rating. You can get field-specific readings on soil quality in the Schedule window.

PROPERTY MAP

The Property map lets you buy and sell land. Clicking on the Property button (with the picture of a nice little field with water adjacent), places a grid pattern over the entire territory, revealing (on a color computer) your plots in green, the town plots in blue, and all the others, ready for purchase. (The **"H"** and **"T"** signify the placement of your homestead and the town as well.)

Clicking on any unowned grid square will highlight it and bring up its sale price in the Land Value bar below the buttons. Land prices depend on soil and water quality. After selection, clicking on the BUY button seals the transaction and the purchase price is subtracted from your funds. Use this command when you're feeling empire-hungry. Or use its counterpart, the SELL button, to sell when you're just plain hungry. Sold land will lose its green highlight in the Property view and will lose its fence line in the Edit window. You can only build on your own property and you can only sell property that has first been cleared of buildings, structures and fields.

You can't sell your homestead plot, so don't even think about it, buster!

SOIL TOXICITY MAP

Clicking on the Soil Toxicity button, the darling one with the skull and crossbones, will display the varying amounts of toxic substances in all the squares. Take caution when adding to fields already chockablock with chemicals—crop values will decline.

SOIL NUTRIENTS MAP

The Soil Nutrients button reveals the presence and various levels of nutrients in all the plots. You can see what soil looks like a promising buy, and also whether it might be time to tell your cows to work overtime to produce some good fertilizer for sagging soil.

CROP DISEASE MAP

The Crop Disease button (with the ragged ear of corn) can be clicked to display the amounts of crop diseases—like fungi and viruses—that are present in the various plots. Diseases are treatable with fungicide, though the land will object to heavy toxic assaults.

WEEDS MAP

The Weeds button (the one on the top-right side with that scraggly old weed on it) gives you information on the severity of weed infestation in your fields. Judicious use of herbicide will counter the woeful weed and save your tender hands for typing commands.

GROUNDWATER MAP

The Groundwater button (the water droplet) reveals levels of groundwater in your soil and the surrounding territory.

FIELD PROFIT MAP

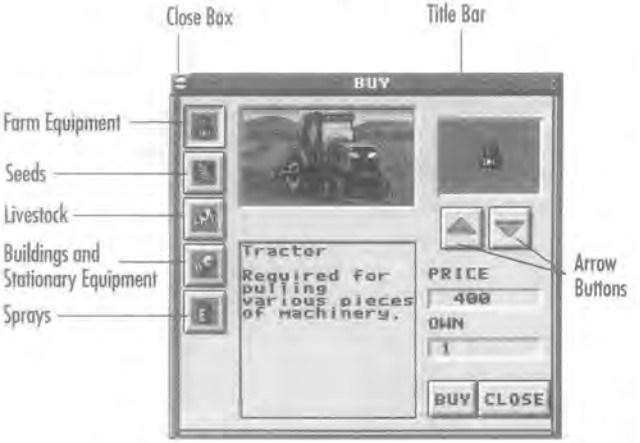
The Field Profit button, adorned with the dollar bill, displays the profitability of your various fields.

PESTS MAP

The Pests button, with the slinky centipede, tells you everything you want to know about pests in the plots.

BUY WINDOW

The Buy window gives you a chance to fill your farm with goodies galore. Along the left side of the window is an icon strip with five buttons that access various types of goods native to farm living. The large picture at the top middle of the window is an image of the selected item, with a description detailed below. To the right of the large picture is a picture of how the selected item will look when it's placed on your property. The scroll arrow buttons below that will, when clicked, cycle you through the articles within each button category: machinery, seed, livestock, structures and sprays.

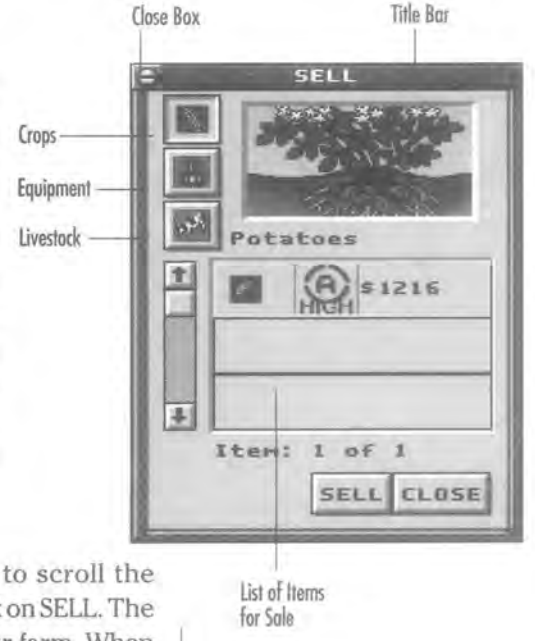


Below the arrow buttons is a text box with the item price and below that a text box revealing how many of that item you currently own. When you find the commodity you just can't live without, click on the BUY button, and your cursor will become a dollar sign. The next place you click in the Edit window will place your purchase. Additional clicks buy you more of the same, so unless you want to open a used tractor lot, go light on the mouse-button.

You must place your purchases within the boundaries of your property line, and if you're going to buy a bunch of critters, fence 'em in first—or your harvest is their lunch. If you buy storage buildings, you will better preserve the value and life of seeds and equipment. Barns will keep your animals a little healthier as well. See the Equipment and Supplies and the Livestock chapters for methods of use and statistical information on every item available in the Buy window.

SELL WINDOW

The Sell window is where you can realize some of the fruits (and vegetables) of your ventures by getting some cold cash for your farming and animal husbandry efforts, as well as get a partial return on old equipment. For both harvests and livestock, the sell price is the average between the market price and the age (condition) of the item.



The three buttons at the window's top-left represent the categories of items that can be sold: crops, equipment and livestock. Clicking on one of these buttons displays the goods you have for sale.

Below the large image is a scrollable list of the items in that category that are in your possession and available for sale. Whether the item for sale is a tractor, a corn harvest or a beautiful bossie, the list displays: a small icon representing the item; the item's condition (given as a grade from High to Fair to Poor to Bad); and the current price.

Click on the scroll arrows to the left of the list to scroll the highlight box to the item you want to sell, then click on SELL. The sold item will disappear from the list and from your farm. When you've sold off all of your harvests a "Nothing for Sale" notice will appear in the list area.

Be sure to canvass the Sell window occasionally to realize the highest prices for your goods; everything in SimFarm, like everything anywhere, is subject to time's sharp blade: the value of all goods, from crops to machinery to animals, is sliced by time, and knowing when to sell is knowledge that leads to success.

EVALUATION WINDOW

The Evaluation window spells out just how you're doing, and—like it or not—comes up automatically at year's end, though it will quickly zip away. You can also access it by clicking on the thumbs-down/thumbs-up button under the menu bar.

The Evaluation window provides an overview of your progress for that year compared with the previous year. The thermometer-style Low/High bar graphs specifically detail: Farm and Town Growth, Farm Productivity and the Soil and Environment Quality. The Soil Quality gauge refers to the nutrient levels in your fields, while the Environment Quality registers the presence of toxins. On a color monitor, if the bar is green, it indicates a positive growth in the thing measured as compared to last year's reading; if it's red, indications are negative. On a black and white monitor, well, we have confidence that you can figure it out. No bar whatsoever tells you that you have neither progressed nor regressed in that characteristic compared to last year. The present season is indicated to the right of the bar graphs.

Below this information are some icons that graphically indicate any real-time problems in your fields and that suggest crops that would do well in the season to come. These indicators are generalizations for all of your fields collectively, and reflect the Map window information. You can obtain field-specific information in the Schedule window. Of course, as an independent farmer you could ignore this window and plant and spray just as you please, dadburn it, but do take its counsel under consideration.

To keep aphids away from roses, plant garlic and mint near the roses.

Courtesy of Old Farmer's Almanac

WEATHER WINDOW

The Weather window is one of the most colorful windows in SimFarm—and it's very useful for short-range planning. It is solely an information window; there are no commands or integral game functions.

The top bar of the window provides the current week and month, with iconic representations of the current season and season to follow. Underneath is a digital readout of current Fahrenheit and Celsius temperatures, accompanied by a thermometer display of both those measures. Below that is a water evaporation rate gauge with an accompanying text box. The window's center gives a pictorial rendering of current weather conditions (note the changes in the plant over time), with a five-day forecast below. This matches and extends the three-day readout in the Control bar. Yearly rainfall totals and current wind speed measures can be found to the right.

The Weather window is a dandy place to do some cloud gazing in your SimFarm world, and it does provide useful information about whether your fields are soon to get doused with rain, and why plots are dried out or have lots of groundwater. But if you have your game Speed set to anything more than Slow, it's likely that time is passing at such a rate that five days of weather might only seem long enough to water a house plant, much less douse a field of crops. You have to admit it looks pretty, though.

SIM Farm

BALANCE SHEET

The Balance Sheet window (chosen from the Windows menu or by clicking on the +/– button) details the season-to-season financial aspects of your farming operation, and supplies some information about town revenues.

Under Assets you can see your cash on hand, the value of your land, machinery, livestock, what you've sold on the Futures market, and a total of all your assets.

The Revenue column is a breakdown of all your income from sales of crops, machinery, land, futures and livestock. The Futures figure here can be markedly different than that in your Assets column because you may have sold Futures deep into the future, and those speculative harvests have yet to see the bottom of a truck. Your total revenues for the game are displayed at the bottom of the Revenue column.

Below that is the estimation of your yearly tax bill, based upon your current holdings, and the amount of your loan payment.

The Expenditures column tallies the costs for seed, machinery, land, any futures losses, farm buildings, livestock and feed, and chemicals. You'll also find the records for the interest on your loans, leasing, and your taxes. Your expenses total is at the bottom of the column, along with your overall profit/loss figure.

Taxes, based on your equipment, property, and your annual income are deducted annually from your funds. Bank interest payments are deducted quarterly. Expenses for operations like bulldozing, fence placement, etc., that are deducted as your incur them are shown under Miscellaneous.

Warning! You are unable to pay your taxes. The Tax Board will force you to sell assets if you don't pay in the next three (3) months.
OK

You will receive notices from the simulation when your bank account is looking a bit skinny on your tax payments towards the end of the year, and if you don't do something about it, your assets, including your land, will be automatically sold off.

Check into the Balance Sheet window every now and then to see where the money went and if any came back on the rebound. You can determine if you have placed an undue emphasis on some expenditures without much of a return, and of course, your profit/loss figure will indicate whether you should get into venetian blinds manufacture rather than farming. Don't worry if you don't seem to be making any money early on though, because it can take a stretch of time before a farm really starts putting out.

BANK WINDOW

The Bank window (opened from the Windows menu or by clicking on the sliding dollar button) is where you can put wheels on your deals, though if you don't watch your debts, all your tires will be flats. The Bank window looks somewhat like an ATM machine window, with some obvious differences: your game funds are totaled at the top, with your debt total and credit limit below. Your credit limit is based on the value of property you own and your assets, minus any outstanding debts. The current interest rate is below that (it fluctuates between 5 and 15 percent), along with the amount of your quarterly payment. Click on the window's number keypad or on your keyboard to arrive at a loan figure and the Loan Amount text box will display the amount of your new loan. Click on OK or hit Return to seal the deal.

The fresh cash will appear in your Funds. Bank loan payments will be deducted quarterly over a five-year term, or you can choose to pay back your loan in its entirety by clicking on the REPAY button. If you don't have enough *moo*lah in your account to pay for the automatic deductions, a dialog box will appear telling you that you don't have enough money, and you'll be presented with suggestions for another loan (didn't our country get in trouble this way?), or to sell equipment or land. Evading your taxes will bring Tax Board agents who will forcibly sell your land and assets. (You'll get impolite warnings on-screen.) If none of those options can be exercised, your farming career is kaput, for this game at least. Lucky for you, there's always another game.

MARKET VALUE WINDOW

The Market Value window, opened through the Windows menu or by clicking on the button with the positive-looking business graph, displays the information you need to make decisions about selling in the futures market. This information includes current market prices for crops, and their price history, charted over the past 30 weeks.

Clicking on any of the crop icons brings up its name, current futures price, chart history and trend, and the number of futures you currently own of that crop. The stated price is for the sale of a single harvest of high grade.

This window is for gathering information on crops, prices and trends. Actual futures sales are performed in the Schedule window using the Contract button.

FARM EXPERT WINDOW

The Farm Expert window is your information resource for general farming know-how. Open it from the Windows menu when you want detailed data on your crops (their growing phases, nutritional needs, values), farm dynamics, machinery, etc.

Click on any of the five icons—tractor, silo, cow, corn or pesticide—to get to specifics about machinery, structures, livestock, crops, and chemical additives. The other picture is Farmer Joe. He knows everything there is to know about farms—and owns the tavern in the local town.

The NEXT and PREVIOUS buttons cycle you through all of the items for each category, and the CANCEL button will return you to the opening Farm Expert screen.

The material found in the Farm Expert window is compiled from actual farm practices and resources, and was used as the basis for the behaviors of the crop mechanisms and other farm actions in SimFarm. It is in your best interest to consult with the Farm Expert window to separate fact from fancy.

SCHEDULE WINDOW

The Schedule window is opened for one field at a time from the Edit window, by clicking on a field after clicking the Magnifying Glass button. It is the true meat and potatoes (and sorghum and soybeans, and all that other stuff) of your farming enterprise. It gives you the power to arrange all of the crop procedures for multiple fields years into the future. It is also where you schedule your sales on the futures market. You can play SimFarm without ever using the Schedule window, but gaining a mastery over (or even a moderate competence in) this window is the primary means to farm success.

WHY SCHEDULE?

Once you have two, three, ten or more fields, farming can become quite hectic. Between planting, harvesting, conditioning the soil, expanding your territory, and minding the livestock, there's no time for the strategic planning that successful farming requires.

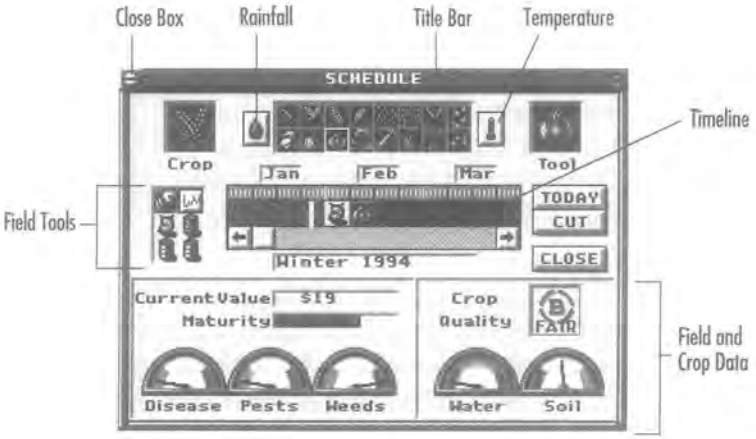
The Schedule window automates the fundamental processes of plowing, planting, harvesting and marketing. It lets you manage your farm, so your can leave the actual plowing and planting to your hired Sims.

Smoke that hangs near the ground is usually an indication of falling pressure and unstable air.

Courtesy of Old Farmer's Almanac

FIELD SCHEDULING ACTIVITIES

Here's a quick once-over of scheduling, planting, harvesting and general crop and soil care.



The top of the window displays icons of the crops currently loaded into the game and available for planting. To the far-left and far-right of the crop icons, respectively, are indicators of the crop currently being grown in the field and the currently active Schedule window tool.

To the immediate-left and immediate-right of the crop icons, respectively, are buttons that show valuable crop data. The Rainfall button superimposes the number of days each crop requires over the crop icons, and gives the weekly rain forecast (in number of days per week) on the schedule bar below. The Temperature button superimposes the minimum average temperature each crop requires over the crop icons, and gives the weekly average temperature forecast on the schedule bar below. This information is useful for choosing crops to plant at different times of the year.

The middle section is the timeline. The timeline displays three months at a time. You can use the scroll arrows to move the timeline forward or backward. The months appear above the timeline, the season and year below. Just below the months is the time ruler measuring off the days and weeks. On color monitors, a yellow line shows the boundaries between months. To the right of the time ruler is the TODAY button. Clicking on it returns the display to "today" in SimFarm time. Below the time ruler is the schedule bar. A bright yellow stripe marks the current stage of farming operations on the field.

THE TIMELINE

To schedule planting, click on the crop you want to plant (the icons at the top of the window), then click on the schedule bar at the time when you want planting to occur. The schedule bar will fill with the stages of the crop's growth, until it is time for harvest, where a silo icon appears. After this, the crop is automatically replanted, grown and harvested, again and again, unless you have no machinery, there is none available for leasing, the field is too fouled by toxins, or some other game activity causes the interruption of the scheduling. You can also stop the cycle by clicking on the CUT button then clicking on the schedule bar at your chosen cut-off time. You can only use the CUT button to affect the future (to the right of the yellow bar).

When crops are harvested, they are stored in a silo, if you have one, or immediately sold at market if you don't.

To the left of the timeline are six tool icons. To schedule any of these field functions, click on the chosen tool icon, then click on the schedule bar when you want it to happen. You can schedule the use of these tools while a crop is growing, or while a field is fallow.

The Harvest tool lets you plan when to harvest a crop if you want a time other than the automatically scheduled one. Of course, a half-grown crop will not get you the pretty pennies of a full harvest, but there can be times when you want to mess with Mother Nature—if a disaster is on its way, you may want to immediately harvest.

The Contract button—the one with the tiny chart on it—lets you arrange to sell your crops on the futures market, a speculative method of investment in your own harvest that can lead to bigger (or smaller) dollars. A complete explanation of the SimFarm futures market can be found below under the heading The Futures Market.

These four buttons represent additives that can be sprayed on your fields: fertilizer, herbicide, fungicide and pesticide. Placing them in the middle of the growing cycle of a crop will not stop the cycle, though it can affect crop yields, either positively or negatively. Be sure to consult the Farm Expert window for specifics on how particular crops react to chemicals. Fertilizing does not add toxins to the soil, but the others do.

FIELD AND CROP DATA

Below the timeline are displays of important information about your field and its crop.

Current Value is the price you'd receive if you harvested the crop at that moment.

The Maturity bar gauge displays the crop's development. When the bar reaches all the way to the right, the crop is fully mature.

The Crop Quality displays the crop's current grade, the same information as you would see for an item in the Sell window. It dynamically reports the status of your crop; crops that are of low quality can be "resuscitated" before harvest if you respond to their needs, be they water, nutrients, chemicals, etc.

At the window's bottom are five gauges that advise you as to the field's environmental quality. If the needle is in the green, the reading is favorable, if yellow, it is more neutral or moderate, and if in the red, your field is screaming, at least for that attribute. The five traits that are recorded are Disease, Pests, Weeds, Water and Soil quality. The Water gauge differs in that its left red bar tells your if your field is lacking water and its right red that it is flooding. The green middle is the sweet waters of Shangri-la.

You can use these gauges in conjunction with the Map window readings and field icons in the Edit window to check the overall quality of your fields.

Your investment of careful and observant time in the Schedule window will prove rewarding. Experiment with crop rotation, fallow fields, and additives and note your results; if your are well-heeled, you could set up a carefully attended and environmentally congenial field against one you hit with every chemical on this and other planets and see what it does to the yields of a particular crop over time. See the Strategies section for elaboration and the Farm Expert window for pertinent crop facts.

SELECT A REGION WINDOW

The Select A Region window is your diving board from which to plunge into the depths of SimFarm. It follows the (have a cow) title screen, and gives you a number of environment-altering options for your opening farm territory. The eight highlighted boxes represent preset scenarios, each with different farm terrains and conditions. Anywhere else you click within the map of our states united has its own weather conditions, which will be detailed in the bar graphs to the map's left. Those conditions will generalize the weather for similar zones in the U.S. These displayed weather factors will play a large part in the look of your game landscape:

for example, a site with low rainfall, high temperatures and high wind speeds is likely to be rocky and dry; lower readings for temperature and wind will have more trees and more fertile soil.

Below the meteorology bars are several buttons.

USE THIS REGION delivers you to the zone you chose on the map, opening a new game or starting a scenario.

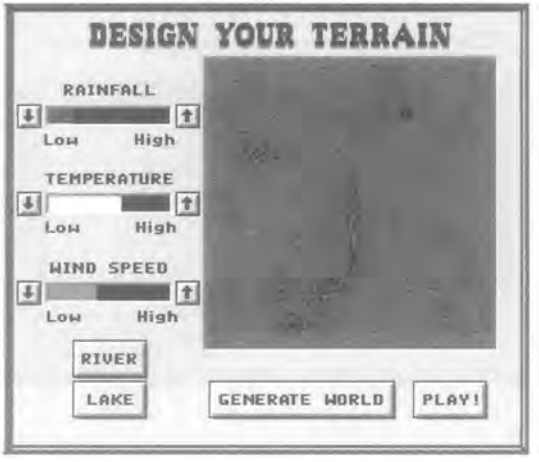
DESIGN YOUR OWN puts you in the Design Your Terrain window (see below), in which you can further refine your farmland.

LOAD A SAVED GAME opens the Load Game dialog box, from which you can select a farm whose roads you've driven down once or twice before. You have to save at least one game before this command is useful.

QUIT is just for whiners—when the going gets tough, the tough get farming. (That phrase is not trademarked, in case you want to use it at dinner parties.)

DESIGN YOUR TERRAIN WINDOW

The Design Your Terrain window is where you'll go if you take the risk and choose DESIGN YOUR OWN in the Select A Region window.



The Rainfall, Temperature and Wind Speed settings for your new farmland can be increased or decreased by clicking on the up/down arrow buttons.

The RIVER and LAKE buttons, when clicked, place a river and/or lake in the SimFarm world. They can both be selected, or you can choose to have neither.

GENERATE WORLD generates the terrain and produces a pictorial representation of your choices in the window—if you're not satisfied, click on it again and your landscape cards will be reshuffled for a new deal. You must click here to generate the terrain after setting Rainfall, Temperature and Wind Speed. If you just set the sliders then click PLAY! it will begin the game with the terrain currently in the picture.

PLAY! begins the game with the terrain that is currently in the picture.

LOAD CROP WINDOW

The Load Crop window lets you choose and change which crops are active in the game. There are 24 total crops, 16 of which can be active at a time.

This window lists all the available crops, and shows icons that represent currently loaded crops. Click on the scroll arrows to select the crop you want to load, click on the crop icon you want your selection to replace, and then click on REPLACE. You can change crops during a game, but you can't replace a crop that is currently growing or has been harvested and is stored in a silo, or if you own seeds from that crop.

E. B. White to chicken farmers: "Be tidy, Be brave. Walk, don't run. Never carry any strange object into the henhouse with you. Don't try to convey your enthusiasm for chickens to anyone else. Always count your chickens before they are hatched."

Courtesy of Old Farmer's Almanac

EQUIPMENT AND SUPPLIES

Managing your machinery and your supplies is an integral part of your farming fortunes, and their mismanagement will lead to your misfortune. The following information covers the basics of buying, selling and making the most of your farm's possessions.

MACHINERY

Gone are the days of the horse-drawn plow—at least here in SimFarm. Your fields are worked by machines, either purchased or leased (although a few crops are harvested by hand). Purchased equipment has to be placed on your property, either on bare land, a road, or in one of your sheds. If you see that some equipment won't be used often, store it in a shed to preserve its value.

Each piece of machinery has different characteristics, including how it ages indoors and out, and how much weather resistance it has. The results of any depreciation can be obtained by clicking with the Magnifying Glass (Examine) tool on each machine. If you haven't provided roads for any machines put into action on your farm, the machines will take the most direct route, and will sustain damage that reduces their value.

You can also view the condition and value of your equipment in the Sell window, where their current stages of High, Fair, Poor, and Bad and their accompanying sale prices are detailed. Bad machinery can't be used, nor repaired. Be alert to aging items so that you can sell them, if even for a pittance, before they break down. When they reach their maximum age, they ain't gonna work no more. Fill your farm with the following and keep our economy solvent:

TRACTOR

Used for pulling plows, planters, sprayers and trailers
Cost New: $400
Requires: Nothing
Occupies: 1 tile

PLOW

Used to ready a field for planting
Cost New: $200
Requires: Tractor for pulling
Occupies: 1 tile

PLANTER

Used for planting seed in fields
Cost New: $200
Requires: Tractor, Seed
Occupies: 1 tile

SPRAYER

Used to spray fertilizer, pesticide, herbicide, fungicide
Cost New: $200
Requires: Tractor, Choice of Fertilizer, Pesticide, Herbicide, Fungicide
Occupies: 1 tile

HARVESTER

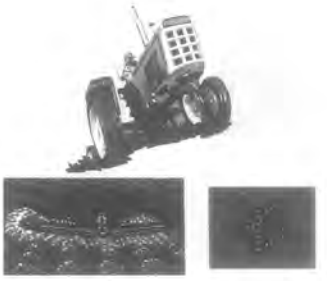
Used to harvest crops from fields
Cost New: $400
Requires: Trailer, Truck
Occupies: 2 tiles

TRAILER

Used for transport during harvest process
Cost New: $200
Requires: Harvester
Occupies: 2 tiles

LARGE TRUCK

Used for transporting harvests to silos or market
Cost New: $500
Requires: Nothing
Occupies: 2 tiles



CROP DUSTER

Used for spraying multiple fields
Cost New: $6,000
Requires: The town must have grown large enough to build an airport.
Occupies: Its own airport near town

For you weary, earth-bound farmers, here's your chance to get above it all.

The crop duster is a pricey item, and it actually should only be used when you have many fields active that all need a dose of fertilizer or fungicide or whatever, but if it's time, choose the plane, click on BUY in the Buy window, and another window will open telling you where your plane is parked. Click OK, exit the Buy window and scroll over to the town, where you'll see a modest airstrip and your new plane.

Click on the plane and a window will open that has picture-button controls: clicking on the gas pump icon will fill your flyer with gas, clicking on either the ugly bug, weed or corn and then clicking on the ugly chemical tub will fill your spray tank with the chemical cure for the pictured condition, and later, if you've flown and incurred any damages, clicking on the wrench icon will repair them. The same type of green/yellow/red = good/neutral/bad gauges found in the Schedule window display the plane's current condition.

Just fill it with petrol and pesticide and click on FLY! Direct your flight with the keypad left and right arrow keys; the plane will travel in the arrow's direction, making quarter-turns for each click of the keys, i.e., from north to northeast, etc. PAGE UP and PAGE DOWN will raise and lower the plane's altitude. Remember that recreational flying will be very expensive.

Hit the HOME button when you want to release pesticide; hit it again when you want the spraying to stop. After you've doused your crops with a couple of applications, decrease your altitude and head back over to the airstrip. If you are low enough, hitting the END button when you're over the airstrip will settle it nicely back down. If you can do this on your first run-through without making the plane a heap of mangled metal, I don't know why you're reading this manual anyway—obviously, you're a born pilot. Keep 'em flyin' (and growin') captain.

STRUCTURES

You can buy structures just as you do machinery, but they can't be sold. You can always demolish them with your bulldozer if they're obstructing your progress or your view. They can only be placed on bare land on your property. For protection against the elements, manually store equipment in your sheds with the Move command, or click directly on the building itself after buying your equipment in the Buy window. Seed should be stored directly in the sheds for safeguarding as well. Sheds have a fixed storage capacity (see below).

SMALL SILO

Used to store harvests
Cost: $800
Capacity: 1 harvest

LARGE SILO

Used to store harvests. Both small and large silos can explode if filled with certain crops and weather conditions are right. Duck and cover!
Cost: $2,400
Capacity: 4 harvests

SMALL SHED

Used to store machinery and seed
Cost: $1,200
Capacity: 6 items

LARGE SHED

Used to store machinery and seed
Cost: $1,440
Capacity: 9 items

SMALL BARN

Used to store sprays, seed, and livestock. You can store machinery in barns, but they make expensive garages.
Cost: $2,250
Capacity: 9 items

LARGE BARN

Used to store sprays, seed, and livestock
Cost: $2,520
Capacity: 12 items

Save toilet paper tubes, cut them in half, fill with potting soil, and stand up in a tray. Use for planting seeds. When young plants are ready, plant them, tube and all. The tube helps stop cutworms.

Courtesy of Old Farmer's Almanac

WATER PUMP

Pumps water from natural sources with the aid of irrigation ditches. Place the pump right on the water source. For increased pressure over very long distances, you can add another pump close to your water's destination. Floods will disable the pump and destroy irrigation ditches.
Cost: $1,000

WINDMILL

Used as a water source. Its capacity depends on placement—it pumps well water. Windmill water will flow through any water ditch placed in front of or one tile below the mill; flooding could occur if no ditches are placed. They require winds of 10 mph to work.
Cost: $2,000

WATER TOWER

Used to store water for livestock. It must be filled by a water source, such as a flowing irrigation ditch placed next to or in front of the tower; it will keep any water troughs on your land filled if the ditches flow. Water towers can burst and cause flooding.
Cost: $200

SPRAYS

You can be the mad scientist and mix and match Fertilizer, Pesticide, Herbicide and Fungicide for your famished fields, though too much of a good thing can bruise the land. Additives can be put on fields manually with the Spray button in the Edit window or automatically in the Schedule window. Try leaving lands fallow or rotating your crops to return nutrients to the soil and reduce your use of chemicals. Cost: $200 per application.

To repel slugs and snails, spread crushed dry eggshells around plants. The slugs won't cross this barrier.
Courtesy of Old Farmer's Almanac

CROPS

SEEDS

Seed prices vary according to current market value of harvests: high harvest value, high seed cost. You could make a good deal on seed by buying a quantity at a low price; otherwise, seed is purchased automatically at planting with the default AutoBuy option. All seed is subject to deterioration and should be stored in sheds.

CROP INFORMATION

There are 24 crops available for planting, 16 of which can be loaded into the game at any one time using the Load Crop window. Like real-world plants, they grow best under optimum conditions and are subject to all of the dynamics of weather and touchy soil.

Note: All the data given for SimFarm crops are based on the data for real crops, but much simplified for the simulation, and somewhat changed for the sake of game play. Don't expect real crops to mature in the same amount of time or with the same amount of water or sun. We apologize to the real farmers and gardeners out there, but heck, after all, it IS a game.

Growing Weeks—the number of weeks until the crop is ready for harvest.

Temperature Requirements—this is usually, but not always given in either "Degree Days" or "Chill Hours." They aren't really measures of days or hours, but those are the official agricultural-science terms.

Degree Days are the total number of average degrees that your plants are exposed to, above and beyond the baseline temperature, which in SimFarm is 50 degrees Fahrenheit. For example, take a crop that requires 1000 Degree Days during its growth cycle. This means that for the crop to properly mature, it needs quite a few days with an average temperature above 50 degrees—but not 1000 days. If, on a given day, the average temperature (day and night) is 60 degrees, that's ten degrees above the 50 degree baseline. So after this day, you can subtract ten degrees from the

remaining Degree Days. If the next day's average temperature is 90 degrees, you can subtract 40 degrees from the remaining Degree Days. If, however, a day averages 40 degrees, you must add ten degrees back to the Degree Days. Chill Hours are like Degree Days, but opposite—they are the total number of degrees below freezing (+32 degrees) that the crop needs during its growth cycle. For some crops, there are no given Degree Days or Chill Hours—just keep them from freezing.

Water Requirements—the minimum and maximum amount of water the crop needs during the growth cycle to fully mature. The amount is given in rainy days—but it's not that simple. These are the amount of rainy days the crop would need if there were no evaporation. In SimFarm, rainy days average 1/4 inch of rain a day. Evaporation can range from zero to 1/2 inch of water a day, depending on the temperature and wind. If your growing season for the crop is a hot, windy summer, you'll either need a lot more rainy days or a lot of irrigation. When you pick your crops and planting times, be sure to take rainy days, heat, wind and evaporation into account.

Pest, Weed and Disease Resistance—crops have either high or low resistance to each of these potential problems.

Harvest Storage Temperature—is the preferred temperature or range of temperatures for storing the crop. If one number is shown, storage is best right at that temperature. Anything above or below that temperature will cause crop deterioration and loss of value. If a range is shown, storage is best within that range. If you see ≤ before a number, then the crop needs to be stored at or below the number. If you see ≥ before a number, then the crop needs to be stored at or above the number.

Replant Every Harvest?—this is "No" for crops like trees and grapevines, which continue to produce for multiple harvests, and "Yes" for crops that must be replanted after every harvest.

General Information—hints and tips on when and where to grow the crop.

THE CROPS

Almonds
Growing Weeks: 30
Temperature Requirements: 300–500 Chill Hours
Water Requirements: 4–7 Days
Pest Resistance: Low
Weed Resistance: High
Disease Resistance: Low
Harvest Storage Temperature: +40
Replant Every Harvest? No
General Information: Almonds grow well in Northern California and similar climates.

Apples
Growing Weeks: 17
Temperature Requirements: 900–1500 Chill Hours
Water Requirements: 5–8 Days
Pest Resistance: Low
Weed Resistance: High
Disease Resistance: Low
Harvest Storage Temperature: +32 to +42
Replant Every Harvest? No
General Information: Best planting regions for successful apple crops are from the Canadian border of Ontario to the Mississippi Valley; Virginia; and Northern California to Washington in rich fertile soil. Plant for Spring (March) and Fall (late October to early December) harvesting.

Barley
Growing Weeks: 34
Temperature Requirements: Avoid freezing
Water Requirements: 1–3 Days
Pest Resistance: High
Weed Resistance: Low
Disease Resistance: High
Harvest Storage Temperature: +50 to +60
Replant Every Harvest? Yes
General Information: Barley is a grain crop. Avoid frost. Stores very well in silos. Watch for good market values before selling.

Carrots
Growing Weeks: 17
Temperature Requirements: 1800 Degree Days
Water Requirements: 3–4 Days
Pest Resistance: Low
Weed Resistance: Low
Disease Resistance: Low
Harvest Storage Temperature: +34
Replant Every Harvest? Yes
General Information: Carrots prefer warm weather. If planted during hot weather, keep the fields irrigated. Try not to plant carrots during long periods of cold temperatures.

Corn
Growing Weeks: 12
Temperature Requirements: 2000 Degree Days
Water Requirements: 8–9 Days
Pest Resistance: Low
Weed Resistance: High
Disease Resistance: High
Harvest Storage Temperature: +50
Replant Every Harvest? Yes
General Information: Corn removes a lot of nutrients from the soil. Keep it well-fertilized, or plant it in rotation.

Cotton
Growing Weeks: 12
Temperature Requirements: 850–900 Degree Days
Water Requirements: 8–12 Days
Pest Resistance: Low
Weed Resistance: Low
Disease Resistance: High
Harvest Storage Temperature: +40 to +120
Replant Every Harvest? Yes
General Information: Plant in mid-to late-Spring in warm climate regions when ground is warm and danger of frost is over.

Gladiolus
Growing Weeks: 12
Temperature Requirements: Avoid freezing
Water Requirements: 8–12 Days
Pest Resistance: Low
Weed Resistance: Low
Disease Resistance: Low
Harvest Storage Temperature: +40
Replant Every Harvest? Yes
General Information: Gladiolus need soil that is rich in nutrients. Fertilize four times during growth, with the last one right after they flower. Do not flood fields with water. Cease all irrigation two weeks before harvest.

Grapes
Growing Weeks: 22
Temperature Requirements: 3000 Degree Days
Water Requirements: 3–5 Days
Pest Resistance: Low
Weed Resistance: Low
Disease Resistance: Low
Harvest Storage Temperature: +36 to +45
Replant Every Harvest? No
General Information: Plant in early Spring. Do not fertilize at time of planting.

Lettuce
Growing Weeks: 13
Temperature Requirements: 1600 Degree Days
Water Requirements: 4–6 Days
Pest Resistance: Low
Weed Resistance: Low
Disease Resistance: Low
Harvest Storage Temperature: +34
Replant Every Harvest? Yes
General Information: Lettuce matures best in cooler temperatures. Time the plantings carefully.

Oats
Growing Weeks: 34
Temperature Requirements: Avoid freezing
Water Requirements: 2–3 Days
Pest Resistance: Low
Weed Resistance: Low
Disease Resistance: Low
Harvest Storage Temperature: +34
Replant Every Harvest? Yes
General Information: Oats are a grain crop, and sensitive to over-watering. Avoid frost. Stores very well in silos. Watch for good market values before selling.

Onions
Growing Weeks: 22
Temperature Requirements: 2700 Degree Days
Water Requirements: 3–4 Days
Pest Resistance: High
Weed Resistance: Low
Disease Resistance: Low
Harvest Storage Temperature: ≥+32
Replant Every Harvest? Yes
General Information: Onions can be planted in both January and June for both a good winter and summer crop.

Orange Trees
Growing Weeks: 47
Temperature Requirements: Avoid freezing
Water Requirements: 3–5 Days
Pest Resistance: Low
Weed Resistance: Low
Disease Resistance: Low
Harvest Storage Temperature: +38 to +45
Replant Every Harvest? No
General Information: Do not plant orange orchards up against fences. Leave one or two tiles between orchards so that cool or cold air can flow through them to help prevent fruit damage. It is best to fertilize prior to planting and to stop all fertilizing 8 weeks prior to harvest. Pesticides, fertilizers, herbicides and fungicides should be applied in warm weather. Pesticides and fungicides can be applied right up to harvest time.

Peanuts
Growing Weeks: 22
Temperature Requirements: Avoid freezing
Water Requirements: 3–4 Days
Pest Resistance: High
Weed Resistance: Low
Disease Resistance: Low
Harvest Storage Temperature: +15 to +70
Replant Every Harvest? Yes
General Information: Peanuts are highly susceptible to cold weather and do much better in warm climates. Don't plant during the cold winter months.

Potatoes
Growing Weeks: 17
Temperature Requirements: 2400 Degree Days
Water Requirements: 5–8 Days
Pest Resistance: High
Weed Resistance: High
Disease Resistance: High
Harvest Storage Temperature: +34
Replant Every Harvest? Yes
General Information: Potatoes are shallow rooted and require frequent irrigation—but too much water can cause rotting. Rotate with soybeans or peanuts every two or three years to add nutrients to the soil.

Rice
Growing Weeks: 25
Temperature Requirements: 2400 Degree Days
Water Requirements: 10–13 Days
Pest Resistance: Low
Weed Resistance: Low
Disease Resistance: Low
Harvest Storage Temperature: +50
Replant Every Harvest? Yes
General Information: Rice prefers warm, dry weather. Fertilize the soil before every planting, or rotate with grain crops. The grains may not grow well, but they will provide nutrients for the rice.

Sorghum
Growing Weeks: 22
Temperature Requirements: 105–120 Degree Days
Water Requirements: 3–4 Days
Pest Resistance: High
Weed Resistance: High
Disease Resistance: High
Harvest Storage Temperature: ≥+32
Replant Every Harvest? Yes
General Information: Sorghum is a warm-weather crop—avoid frost. The best planting times are late May and early June.

Soybeans
Growing Weeks: 17
Temperature Requirements: 2400 Degree Days
Water Requirements: 1–2 Days
Pest Resistance: Low
Weed Resistance: Low
Disease Resistance: High
Harvest Storage Temperature: +50
Replant Every Harvest? Yes
General Information: Soybeans are ideal to plant in rotation with other crops because they add nutrients to the soil. Plant soybeans twice a year—once in the first week of February and once in the first week of June.

Strawberries
Growing Weeks: 17
Temperature Requirements: 200–1200 Chill Hours
Water Requirements: 6–10 Days
Pest Resistance: Low
Weed Resistance: Low
Disease Resistance: Low
Harvest Storage Temperature: +34
Replant Every Harvest? Yes
General Information: Strawberries need to be chilled during growth, so frost danger is negligible. Plant when the weather is cool such as in February or March.

Sugar Beets
Growing Weeks: 47
Temperature Requirements: 1800 Degree Days
Water Requirements: 1–2 Days
Pest Resistance: High
Weed Resistance: Low
Disease Resistance: Low
Harvest Storage Temperature: ≤+45
Replant Every Harvest? Yes
General Information: Sugar beets are very sensitive during their early stages of growth. Try not to fertilize during these stages or you might damage the seedlings.

Sunflowers
Growing Weeks: 14
Temperature Requirements: Avoid freezing
Water Requirements: 5–7 Days
Pest Resistance: Low
Weed Resistance: Low
Disease Resistance: Low
Harvest Storage Temperature: ≤+50
Replant Every Harvest? Yes
General Information: Sunflowers are sensitive to fertilizers during the early stages of growth. Wait about six weeks before applying any fertilizer.

Sweet Potatoes
Growing Weeks: 17
Temperature Requirements: 2500 Degree Days
Water Requirements: 6–8 Days
Pest Resistance: Low
Weed Resistance: Low
Disease Resistance: Low
Harvest Storage Temperature: ≥+55
Replant Every Harvest? Yes
General Information: Favorable growing regions are New Jersey southward, Central and Southern California, Arizona, New Mexico and Texas. Harvest only on a dry, sunny day.

Tobacco
Growing Weeks: 30
Temperature Requirements: 2000 Degree Days
Water Requirements: 1–3 Days
Pest Resistance: High
Weed Resistance: Low
Disease Resistance: Low
Harvest Storage Temperature: ≥+60
Replant Every Harvest? Yes
General Information: Plant in fertile, moist soil when all danger of frost is over. Keep soil moist, but not wet.

Tomatoes
Growing Weeks: 13
Temperature Requirements: 200 Degree Days
Water Requirements: 6–9 Days
Pest Resistance: Low
Weed Resistance: Low
Disease Resistance: Low
Harvest Storage Temperature: +55
Replant Every Harvest? Yes
General Information: Plant when weather is warm and stable (+55 degrees Fahrenheit minimum). Keep soil well irrigated. For a longer harvest season, plant two times per year, early July and early October.

Wheat
Growing Weeks: 34
Temperature Requirements: Avoid freezing
Water Requirements: 2–3 Days
Pest Resistance: High
Weed Resistance: Low
Disease Resistance: High
Harvest Storage Temperature: +50 to +60
Replant Every Harvest? Yes
General Information: Wheat is best grown in the Great Plains region because of the intensely hot summers, the number of clear days and precipitation during summer months. Stores well in silos.

LIVESTOCK

There are four types of livestock in the game, which can be raised and sold like crops. They will roam freely, so you must contain their crop-eating selves behind fences. They are all similar in growth rates, food needs and weather resistance. You must maintain a close watch on all of them to ensure that they are well-fed and healthy. If they get the chow they need, you will be able to see them grow in size and value. The females will reproduce if they're in the mood.

Livestock will wander in and out of any barns you've purchased, and the shelter will keep them somewhat healthier and more valuable. If they are ill-cared for, and their grade goes to "Bad" in the Sell window, you can—slowly—build their value back up. If they're feeling particularly hungry or ornery, they can damage your fences and flee to Malibu. If they do escape and get hit by moving farm machinery, you'll see that it broadens their perspective. You can "herd" them with the Move icon hand if you're feeling like a cowboy. They will deteriorate rapidly—and die—if not fed and watered.

COW
Lives 20 years
Eats 1/4 bale of hay each month
Mates after 15–20 months
Gestates for 10 months

PIG
Lives 15 years
Eats 1/8 bale of hay each month
Mates after 8 months
Gestates for 11 months

SHEEP
Lives 10 years
Eats 1/16 bale of hay each month
Mates after 3 months
Gestates for 6 months

HORSE
Lives 20 years
Eats 1/4 bale of hay each month
Mates after 4 years
Gestates for 11–12 months

THE FUTURES MARKET

The Futures option lets you go to Las Vegas while you're still down on the farm—sort of. It can either be a way to maximize your profits or to lose the farm. (The futures market in SimFarm is much simpler than in the real world—and much safer. Don't go off investing your real money on the basis of success in SimFarm.)

The standard way to sell your crops is to harvest them when they're ready, and either sell them right away for the current market price, or put them in storage and wait for the price to go up. Of course, many crops go down in quality and lose their value if stored too long.

The futures market gives you another option, or gamble, if you prefer. It lets you sell your harvest months or years in advance—whether it's still growing or not even planted yet—at the current market value.

You don't collect the cash until you harvest and deliver the crop. When you do harvest and deliver, you will only get the full market price if your harvest is a good one and of high grade. A bad harvest will only bring in a percentage of the market price and a totally lost harvest pays nothing.

Here's the idea: if you think today's market price for a crop is good, and you think that it will be lower at the time you actually harvest, then you can sell your future harvest and lock in today's price.

Of course, the people who buy your futures are betting that you're wrong. They make their money when the price goes up after they've bought it. A lot of factors affect market price, including the quality of other local harvests, the time of year and the weather. Do your research!

Here's how to do it:

1. Check the Market Value window frequently to see how the crop is behaving on the market. Look at the graphs, watch the trends, and try to predict the future.
2. When you think the price is at its peak, and is about to go down, it's time to sell.
3. Sell one or more future harvests by opening the Schedule window for your field, clicking on the Contract button, and clicking on the schedule bar at the time when you want to make the contract. The market price at contract time is locked in.

You will only truly make a killing if the crop's price drops and you've sold a lot of futures, implying that you are planning on planting the same crop for a number of harvests.

Remember: the Market Value window reflects the price of an ideal, perfect harvest, so in order to reap whatever futures price you sow, you must maintain the crop's quality.

A simple and harmless remedy for fire ants: be sure the ground around the nest is dry and no rain is forecast. Sprinkle nest liberally with Malt-O-Meal dry cereal. Do not otherwise disturb nest. The ants eat the cereal, which swells and kills them.

Courtesy of Old Farmer's Almanac

SIM Farm

STRATEGIES

Those of you who have a knack for electronic farming can skip this section, which is teeming with fascinating tips and techniques for tilling that digital earth. But if the only thing you grow well is facial hair, you might want to take a peek at these hints. They contain both broad generalizations about setting up your farms and specific uses of tools and equipment.

GENERAL

When the town expands, you'll have an opportunity to vote for the type of development that will be built on the plot. Your vote usually counts. If you have enough dough for a crop duster, vote for an airport. Crop dusters will save you money when you need to spray multiple fields.

Sell futures. Check the Schedule window to find out the current value of your crop, and compare that to its market value. If your crop's value is high, sell a future and forget about it. You will have guaranteed a price for that crop. Just hope that its market value doesn't go up. And don't forget to maintain the crop.

If you are designing your own terrain, be sure to select a lake or river, or both. These are great water sources. Do consider that farms too close to water are subject to flood damage.

When you see a white horse, kiss your right hand and stamp it twice on your left hand. Money will follow.
Courtesy of Old Farmer's Almanac

Plan for taxes. The town will collect some of your money for maintenance and expansion. Taxes are computed from your total land value, machinery owned, structures built, and profit. If you've bought lots of expensive land, your taxes will rise considerably. You're in a heap of trouble at year's end if you don't have money for the tax man.

Don't use paved roads on your farmland unless you have a lot of land or several non-contiguous plots. Dirt roads are cheaper and don 't need to be bulldozed when you rearrange your farm layout.

Save often! The power still goes out sometimes, y'know....

Buy seed manually. Although there is a default AutoBuy option, seed prices can fluctuate. Buy seeds that can be stored for a long time when prices are low.

Consult the Farm Expert window before planting. The Farm Expert window contains useful info such as ideal crop growth temperatures, moisture requirements, harvest methods, etc.

Stagger the planting of new fields. By planting fields two weeks apart, you can reuse machinery you own. If you plant several fields simultaneously, you will need more equipment, because the fields will all demand plows and planters at the same time.

Always plant trees around every field. Trees protect your soil from wind. Trees will have no effect unless they are within two tiles of your fields. You will need at least eight tree tiles to protect your field.

Use the same ditches to irrigate AND drain your fields. Place a valve in the ditch just before it gets to the field. Turn this valve on and off to regulate water flow and drainage.

Do not "dead-end" ditches into your fields. Instead, run them all the way along one side. The more exposure your field has to the ditches, the more effect they have.

Buy a large silo if you can, rather that a few small ones. Four small silos costs $3200, whereas one large is $2400, with equivalent storage capacity.

Don't let a field whose crop quality has gone to Bad ("X" grade) go to harvest if it's deep into the growth cycle. You will incur use damage to your machinery and take up storage of a crop that has little or no value. If you notice a crop go to the X grade, use the Cut button in the schedule window to leave it fallow, or replant it with another crop.

When you see the breaking wave icon in a field, it's telling you that your field has too much water, and that may prove damaging to crops. If it is a crop that likes things a bit dry, you can use dry irrigation ditches placed the field's length to drain off excess moisture, or shut off the "on" valve from existing ditches. If the icon has appeared because it has been particularly rainy, it should soon disappear without harm.

When the skull and crossbones (old Toxic Tommy) appears in your field, then you've put a lot of chemical additives (toxins) on the land. It simply indicates the presence of these additives, and shouldn't be construed as an evidence of long-term soil damage. Constant use of chemicals will exhaust your field's ability to recover, however, and affect crop values.

The appearance of the cow skull in a field tells you that your field is mighty thirsty. The little bag of manure indicates that your soil is lacking in nutrients and needs fertilization. In SimFarm, fertilization does not increase toxin levels, so you don't have to use a dainty hand with fertilizer if you see soil nutrient levels dropping.

The scrawny old weed icon tells you that your field is full of weeds, and the chewed-up corn tells you that your field is filled with pests. Herbicide and fungicide are the most effective means of dealing with these devils, but spread 'em with care.

MACHINERY

The absolutely necessary machinery for a single field is:

1 tractor
1 planter
1 plow
1 harvester
1 truck
1 trailer

Although some crops don't need a harvester, buy these machines when you first start your farm. After two or three plantings, you will save BIG on leasing costs.

Sell and replace your machinery before it breaks. Low-quality machinery is worth more than dead machinery. Check its quality frequently with the Magnifying Glass (Examine) tool or with the Sell window. You won't notice machinery performance problems until it breaks.

Machinery always tries to enter fields from the upper left-hand corner. Machinery tends to exit the field on the lower-left corner, but occasionally exits on the lower right. It's helpful to place roads along the left-hand side of the field to ensure they can make it in and out of the field with minimal damage.

Turn AutoLease off when you own machinery. This will prevent machinery from being leased when you mess up your schedule. You can always fix your schedule.

If you don't plan on purchasing machinery, build a paved road from the town to your farm. Try to make the road as close to a direct path from the upper left-hand corner of the initial town plot to your fields. This will reduce damage to the leased machinery and lower your leasing costs. (Machinery always leaves town from the upper left-hand corner of the first town plot, no matter how many town plots there are.) Expect the road to be partially destroyed due to the occasional flood and town expansion. Check it every four months (game time).

Use paved roads when you have several non-contiguous plots of land. This will help machinery get to your other plots with minimal damage.

Buy a shed for machinery. It will keep your equipment's value and functionality high.

Machinery will exit sheds from the side closest to the destination field. Try to lay roads from that side of the shed to the field.

For the best-tasting tomatoes you ever ate, pour a cup of beer around the roots of each plant after they blossom. Repeat once a week until tomatoes are ripe.

Courtesy of Old Farmer's Almanac

LIVESTOCK

Take care of livestock. You make more money through breeding than raising.

1) Buy new livestock.
2) Take care of them.
3) Sell them when they're older and after they have produced offspring.
4) Repeat Step 2.
5) Bask in riches and glory.

You don 't need a thousand water troughs to water livestock. Just a couple can water an entire pen if you have a water tower.

Water towers should be placed next to an irrigation ditch that you always keep full (if possible). Floods will occasionally destroy ditches from rivers and lakes, droughts will sometimes make rivers and lakes recede from water pumps, and low winds will prevent a windmill from functioning at all. Water towers will store water for a couple of weeks until you can repair or restart your water sources. If you have lots of livestock and water troughs, you may need more than one water tower.

Place water troughs and feed strategically if you have multiple livestock pens. Livestock are DUMB. If feed in a neighboring pen is closer to the livestock than the feed in their own pen, they will try to go to the neighboring pen. This can cause starvation of animals and destruction of fences, and perhaps make you feel as dim as your beasts.

If you can afford it, buy a barn for livestock. Livestock won't drink or eat as much if they have a barn to enter. It will also raise their value by protecting them from the elements.

Grow enough food to feed the hungry. (I know this isn't a strategy, but I thought I'd give you an incentive.)

REAL FARMS

It brings up happy old days when I was only a farmer and not an agriculturist.

— O. Henry (William Sydney Porter),
The Gentle Grafter, Modern Rural Sports

REAL FARMS

HISTORY OF AGRICULTURE

BEFORE AGRICULTURE

This section of the manual contains information about real farms, from their beginnings around 9000 B.C. to modern times.

Before agriculture, people lived by hunting wild animals and gathering edible plants. When the herds were plentiful and the plants flourishing, life was good. But, when the herds migrated elsewhere, people had to follow them and often discover a whole new set of plants to supplement their diet.

Hunters eventually realized that their prey was much easier to kill if it were walled up in a box canyon. Better yet, they could capture the prey and keep it in a cave for future use. Archaeological finds show that early humans imprisoned giant ground sloths in this way. Entrapment, however, was a temporary measure. Not thinking of the future, hungry humans gorged themselves, then, when the sloths had all been eaten, they sought out more sloths. Maintaining a herd—by breeding and nurturing—wasn't yet practiced.

This "feast or famine" lifestyle had its definite drawbacks—including starvation. Fortunately, several geniuses throughout the world eventually discovered how to preserve meat by drying it, smoking it over a fire, or cooking it. Some others realized that if they took the seeds of the plants they had been eating and scattered them about, they grew into new plants.

Eventually, people decided that life would be a lot easier if they always had the animals with them and if edible plants or their produce were always available. Settling down seemed like a good idea.

THE ORIGINS OF AGRICULTURE

Recent archaeological finds place the beginning of agriculture before 7000 B.C. and animal domestication (mostly dogs used as hunting aids) thousands of years before that. There is some evidence that the people of Shanidar, in Kurdistan, were domesticating sheep and planting wheat as long ago as 9800 B.C.

Intensive food-gathering, in which the local inhabitants of a region set up permanent residences and made extensive use of already-present plants, seems to have started in the Near East around 9000–7000 B.C.

Barring the use of time machines, there is no way to know for sure how planting really got started. But archaeologists have lots of theories. One theory suggests that some seeds were spilled in a memorable manner during a migration. When the tribe next passed the same place, they might have correlated the spill of seeds with the sudden abundance of the plant. They could then have realized that they could store seeds and plant them, and be assured of having a food supply. Later they began selecting and planting the seeds from plants with the highest yield. In this way, plants were domesticated—changed and controlled to benefit man rather than just exist in the wild.

At about the same time as the agricultural advances described above, people started to domesticate the wild ox and gather sheep into herds. Remains of a hunting dog, dated back to 8500 B.C., have been found in North America.

TOWNS AND CITIES DEVELOP FROM FARMING

The abundance of the harvest from domesticated plants allowed major increases in population. Having all of one's plants and animals in one place allowed the agriculturist to move from random caves and makeshift huts into permanent or semi-permanent villages with homes made from stones, wood, or wattle. An early example is the Biblical city of Jericho. It started as such a village around 9000 B.C., and has been a settlement of one sort or another ever since.

One of the earliest recorded towns is Catal Huyuk (Catalhuyuk), established on the Konya Plain in Turkey—a vast, fertile expanse ideal for primitive agriculture. The earliest buildings date from 6500 B.C. and are similar to those found in the oldest Jericho settlements—mud brick buildings entered from the top. Catal Huyuk is notable for the number of shrines used for a variety of purposes, including burial and possible propitiation of deities of the hunt and the harvest. This implies an early religious organization and a way of life that left enough time for some members of the society to concentrate on religious duties. There was also time for crafts. Some of the earliest known pottery was found in Catal Huyuk. There is also evidence of copper smithing and rope-making, and some ovens were big enough to imply that some residents were full-time bakers.

By 5000 B.C., the Euphrates Valley was full of villages and townships. The townships provided central services of storage, religious observance and administration that the villages could not handle. These townships developed into the Sumerian civilization.

At about the same time, similar villages were beginning in the Nile Valley and the river valleys of China and India.

EARLY FARMING TECHNIQUES

The initial approach to farming was to remove some of the seeds from food plants before eating them, then scatter the seeds back into the same area they came from.

Later, the planters realized that other (non-food) plants were competing with their plants for the field, so they took to weeding the fields to make sure that only *their* plants were growing there. Everything else was left to nature.

Eventually it became obvious that this constant replanting resulted in stunted crops and low yields. The first response was simply to find a new field. After all, the land was vast and people were few. After awhile, though, the obvious fields were used up. Then, potential farmers looked to the forests.

FIELD FERTILITY TECHNIQUES

SLASH AND BURN

Most agricultural societies discovered the slash and burn technique. First, all the foliage in a section of a forest was cut down, creating a field. The remains were left on the ground. Then the field was set on fire, and the ash from the cut foliage enriched the soil. After many uses even this enriched soil became barren, and farmers were forced to find new fields.

As the population of the world grew and more fields were slashed and burned, the walk to a newly burned field became longer and longer—and other cultures could claim these unattended fields. The tribe would then have to move to new sections of forest. In some areas, such as Madagascar, slash and burn agriculture is still practiced and the land is becoming less and less fertile.

FALLOW FIELDS

A fallow field is one that is not planted for a period in hopes that it will regain its fertility. It is believed that the practice of leaving fields fallow originated because some cultures were forced to return to their old fields, and found that the infertile fields they left behind had become more productive.

This led to the establishment of a rotation system where each growing season certain fields would be left alone (or perhaps tilled but not planted), extending the useful production life of a set number of fields. Sometimes the fallow fields were used for pasturage for animals, which had the incidental benefit of fertilizing the soil.

It was later found that certain plants, thought useless except perhaps for animal fodder, were beneficial to a field's productivity, and seeds for these plants were planted in fallow fields.

IRRIGATION

As populations grew and competed for the best growing lands, some cultures were forced to try to farm normally arid areas. Some of these cultures died trying; others discovered the prin-

ciples of irrigation. There were some early massive engineering projects to dam water for later use, including the digging of canals to distribute water to normally dry fields. The first known examples of this irrigation process were built by farmers who colonized the Euphrates River Valley around 4000 B.C.

In most cases, irrigation involves trapping and storing water that appears for a short period (such as the spring flooding of the Euphrates and Nile, or the winter rainstorms of the American desert), so that it can be used later in normally dry periods. In almost all cases, early irrigation made the desert flower for a couple of centuries, then the water dried up in some climatic change or the fields grew barren because the irrigation had washed away all the good soil—and the culture died. Both the Pueblo dwellers of the American desert and the inhabitants of Petra in the Middle East flourished and then died with their irrigation systems.

Other areas, such as the very fertile Nile Valley and the Tigris-Euphrates Fertile Crescent, were big enough and had a sufficiently dependable source of water so that they remained productive until the present day, though even these areas have undergone a decline in fertility and might be barren if not for modern agricultural techniques.

PLANTING TECHNIQUES

Initially, primitive agriculturists practiced broadcast sowing, simply taking their gathered seeds and casting them over a field. This was, at best, a chancy method of planting. A strong wind or incursion of seed-eating birds could destroy a crop before it got into the ground.

After a while, farmers started to use sticks to break up the ground, and then invented early hoes and mattocks. Eventually, some agricultural prodigies made the connection between domesticated animals and ground-breaking sticks and they invented the plow: a sturdy stick that can be pulled behind a draft animal such as an ox or horse or donkey. This made life much easier for the farmer, though not for the draft animal.

A plow's primary purpose is to cut into the soil in long ruts, performing two tasks. The ruts loosen the soil so the roots from the seed can take hold and they open up the ground so that the seed can be planted inside the earth rather than left on top. Even in ancient times, some technical wizards had come up with the idea of fastening a funnel to the back of a plow to let seeds drop through, ensuring that they fall into the rut carved by the plow. People without this innovation had to lay the seeds by hand, or broadcast them and hope they fell into the ruts.

Early plows just cut the earth; they didn't ensure that the earth wouldn't close up after them. In an essay on farm procedures written in Roman times, the plower was said to be followed by someone with a mattock, who would break up clods of earth and make sure the ruts stayed clear. Around the year 1000 A.D., wheeled plows were invented in Europe. They had a rudimentary moldboard and coulter to invert the soil and leave a clean furrow, improving the seedbed.

About this time the horse collar (apparently originating in China) arrived in Europe. Earlier all-leather harnesses put the load on a leather strap across a horse's windpipe, cutting its efficiency drastically. The horse collar puts the load on the horse's shoulders, where it belongs (though the horse might have something to say about this). After the horse collar, horses became more common as plow pullers, though poorer farmers preferred oxen because they were less expensive to maintain.

In the first half of the 18th century, the Rotherham plow (supposedly invented in Holland) came into use in England, Scotland and the Low Countries. Its design is essentially identical to plows in use today, though the materials have been updated. The original Rotherham plows were made of both iron and wood.

The first factory that made plows was established in England in 1783. Previously, plows had been made-to-order by blacksmiths.

While the use of plows and domesticated animals spread throughout Europe, Asia and Africa, in Meso-America, where the domesticated animals needed to pull plows were not available, the plow was never invented. Instead, planting involved a laborious process of drilling holes in the ground and dropping the seeds in. Some anthropologists argue that this time-hungry process decreased the time the American Indians might have otherwise spent devising other technologies that may have helped them meet the threat of the European invasion.

DEVELOPMENTS IN FARM MECHANIZATION

Of course, sowing seeds and plowing the ground are just part of the farming process. The resulting plants must be protected from insects and weeds, harvested, in some cases threshed (the food element separated from the rest of the plant by beating the plants) and carried to the market for sale or prepared for consumption on the farm. All of these were backbreaking labors that, when done by hand, took a lot of time and energy.

By 1800, a few threshing machines were in operation, and an English gentleman named Jethro Tull invented the horse-drawn hoe for keeping the ground between rows of wheat weed-free, and a seed drill, which was a more elaborate version of the old seed funnels.

After the 1830s, farm mechanization began to take off. Patrick Bell in Scotland and Cyrus McCormick in the United States devised reapers for harvesting grain, British inventors devised threshing machines that had farm laborers rioting because of lack of work, and John Deere of Illinois invented the all-steel plow that would be the foundation of a farm tool and mechanism empire that is still powerful today.

The advent of steam power in the mid-1800s set farmer-inventors to work on steam plows, steam-powered milking machines and other steam-powered devices. The internal-combustion engine of the 20th century made it possible to create a tractor that could haul various mechanisms about the farm. After the Second World

War, the trend went to self-powered devices, though the tractor is still an essential farm workhorse.

THE BIRTH OF AGRICULTURAL SCIENCE

Initially, farming information went from father to son, from uncle to nephew, and from farmer to farmer in the same community. Philosophers and other theorists had little time for such a mundane activity, though some ancient farming advice has come down to us as part of religious doctrine.

To a degree, this method worked. Farmers got better and better at what they did, but there was no research into why certain practices were effective and others less so. A normally unproductive practice that didn't actually harm the crops might happen to work one year and be continued for generations until someone else figured out that it was actually ineffectual. And, of course, tricks and aids found by one collection of farmers would not be passed on to others, leading to uneven farm production, even among the farmers of one country or province.

While the Roman essayist Pliny and other classical and medieval writers wrote on farming, agriculture was never considered part of the academic structure. Even the natural philosophers of the 18th century thought that a general education was all that was necessary for a farmer—there was little concern with the study of farming as a concept. It was just there. You learned what your father knew and got on with it.

However, as more and more people grew away from the land to become part of an industrialized society, some of them began to study farming as a science. Now, every industrialized nation and most nations whose economies are based on agriculture have regular colleges in which agriculture is taught as a science.

The first established agricultural colleges were started at the turn of the 19th century in Hungary and later in Germany. They were very empirical; the attending farmers learned from the experiences of other farmers. This was simply an extension of the

practice of passing on agricultural knowledge from farmer to farmer. Now, the farmers of an entire country could learn the techniques used by all the other farmers of his country.

In 1840, Justus von Liebeg of Darmstadt wrote the first book on scientific farming. Von Liebeg's concept that the principles of experimental science could be applied to agriculture revolutionized European and American thinking on the subject. Agricultural academies sprang up all over Europe; the first agricultural colleges in America appeared in the 1850s. The Agricultural College of the State of Michigan, which opened its doors in 1857, still exists today as Michigan State University.

The development of these colleges has resulted in a program for academic farm training that is the same all over: a combination of classroom training and practical experience on college-owned farms. Most governments with an agricultural policy maintain learn-at-home courses for farmers who can't take the time to attend school.

Today, the science of farming is split up into five areas of study: soil science, plant production, animal production, economics and management science, and agricultural engineering.

MODERN FARMING

SOIL SCIENCE

If soil is not fertile, crops don't grow. The more fertile the soil, the better crops grow. Soil Science deals with all factors relevant to soil fertility, including the uses of water. Soil Science began with the theory of humus, formulated in 1809. This theory formalized the long-known but poorly understood principle that decayed vegetable matter, called humus, added fertility to soil. In 1840, Justus von Liebeg introduced scientific experimentation with soils, including a theory of the necessity for soil to have mineral nutrients.

Now, the general theory of soil fertility embraces soil cultivation, soil enrichment with humus, soil enrichment with nutrients and soil preparation in accordance with crop demands (which includes water regulation, especially drainage).

Soil Cultivation deals with physically improving and preparing land for crops. This includes breaking up the land with plows, eradicating weeds, preparing seedbeds and aerating the ground to allow oxygen to reach the seeds.

Soil Enrichment deals with adding nutrients to the soil. Nutrients include both naturally decayed vegetable matter, humus and chemical fertilizers. It also encompasses crop rotation schemes that call for planting special crops—usually legumes or grasses used for forage—to fix nitrogen in the soil, which replenishes the soil's fertility.

Soil Preparation deals with irrigation techniques and drainage schemes to keep the water on the crops where it does the most good, rather than running off, being wasted and causing erosion problems. Water regulation deals both with piped-in water and the use of water from rain, flooding and snowfall. Drainage techniques include methods to keep the irrigation-water salts from building up around plant roots and stealing water from them.

PLANT PRODUCTION

Plant production deals with the actual plants, rather than the soil they are grown in. Instruction in sowing dates was recorded in Egypt as far back as 2000 B.C. Greek and Roman classics, medieval herbals and 18th century Rationalist treatises gave instructions on how to achieve higher yields.

In the early 1800s, English researchers started field experiments. About this time, the re-discovery of Mendel's laws of heredity gave growers guidelines for developing new plants and led to modern plant breeding. The modern approach to plant breeding is to find or make varieties that are hardier, more pest-resistant and capable of flourishing in areas where they have not been grown before. Because many nations are attempting to make more use of their deserts, there has been much research into crops with a high tolerance for salinity.

In the 1900s, the world suffered several agricultural disasters, mostly caused by the introduction of plant diseases into areas without immunity against them. These disasters stimulated research into plant diseases and their causes.

Pest control needs led initially to chemical poisons effective against bacteria and insects. The poisons often caused as many problems as they solved, opening the ecosystem to different pests and otherwise harming the environment—traces of the poisons were found in many untargeted animals, including humans. Much research is geared to adjusting the biological balance of the environment to reduce the losses from diseases and pests.

There has also been research into making the fruits of the harvest more palatable to the product-buying consumer, including methods of preservation, to allow the foods to travel further and still be fresh and edible.

ANIMAL PRODUCTION

This aspect of agricultural science concerns the genetics and breeding, nutrition and husbandry of animals.

The first animal used for crossbreeding was the horse. Hittite records from 1600 B.C. from the Tigris-Euphrates area detail breeding programs for chariot horses. In medieval Europe, draft horses were subject to carefully controlled breeding programs. The same methods were used in breeding 18th-century English racehorses.

The science of crossbreeding, bolstered by genetics research, has created a leaner, faster-growing pig, small turkeys to fit into small ovens and several sheep species meant to live in different environments. Methods used for crossbreeding range from simply bringing members of different breeds together to assorted schemes of artificial insemination.

Animal production studies also investigate the feed given to animals in an effort to produce the best animal without putting unfortunate byproducts into its meat or milk.

In the efforts to breed and maintain animals that are not prey to the hazards of open range living, a lot of research has been done in confinement management of animals, in which they are kept in a stall or pen for their entire lives. Some investigations show that confined animals are more prone to disease because of their stressed condition, although, of course, some types of disease prevention are easier with the animal confined into one small space.

ECONOMICS AND MANAGEMENT SCIENCE

This aspect of agricultural science concerns behavioral science, agricultural policy, market research and rural sociology. The concept of a farm being an enterprise, affected by location, production techniques and market factors originated in the 19th century. And in the 20th century the idea became popular that like a business, a farm should concentrate on optimal production

lines (crops) to match the production factors (growing environment, market needs, highest profits) of the region. In other words, farmers used these techniques to specialize in crops that would bring in the most money.

Behavioral Science has been used to examine the psychological causes of problems in farm managers' decision making.

Agricultural Policy has been applied to the problems of increased production in the face of decreased rural population. It usually involves governmental policy toward loans to farmers, price supports for farmers and governmental sponsorship of research into machinery and improved crops.

Market Research is used mostly to study past statistical market trends in order to forecast production needs.

Rural Sociology is a relatively young discipline, originally fostered in the United States, but now present in virtually every country. Data from these rural studies is used in determining agricultural policy.

AGRICULTURAL ENGINEERING

This aspect of agricultural science includes various areas of mechanical engineering, construction, hydraulics and soil mechanics. Its roots lie with the ancient canal makers and irrigation ditch diggers, but it has become a scientific discipline in the last century. This discipline has four areas of concentration: farm power and machinery, farm structures, soil and water control, and electric power and processing.

Farm Power and Machinery deals with the design and construction of power systems and specialized farm machinery such as harvesters, electric brooders and other equipment that is now part of any modern farm.

Farm Structures deals with the design and construction of farm buildings, barns and specialized buildings, as well as fencing.

Soil and Water Control deals with the problems of drainage, irrigation, soil conservation, hydrology and, to some extent, flood control. This is the nuts and bolts aspect of the water-control problems studied under Soil Science, as discussed above.

Electric Power and Processing deals with the distribution and application of electric power on a farm.

MODERN PROGRESS IN FARMING

Where it had taken centuries to devise such improvements as the horse collar and the metal plow, scientific developments in agriculture multiplied on a yearly basis as agriculture caught up to the scientific method. Some developments were rushed into the field without adequate long-term testing and others have brought up intense philosophical debate, but there is no doubt that the face of farming has changed immensely in just the last century.

CROP ROTATION

Reviving a failing field by leaving it fallow was discovered long ago, as described earlier. However, shortly before the end of the 17th century, the Norfolk four-course system was invented. First put into practice in Norfolk County, England, on the newly enclosed farms; by the early 19th century it had spread throughout much of Europe and the United States. Variations of this system are still in use today.

The four-course system calls for wheat (or some other major crop) to be planted the first year, turnips (used for feeding cows or sheep) the second year, then barley with clover and ryegrass undersown in the third. The clover or ryegrass was either used for grazing the fourth year, or cut for feed. This process has a cumulative effect, because the feed crops produce better animal manure, which enriches the field. Besides the benefit to the crops, the animals are better fed and healthier.

PEST CONTROL

Unfortunately, agricultural products are prey to many hazards, especially insects. Insects are a common menace to the farm throughout the growing process. It seems that there is at least one insect that preys upon every crop developed to provide for our needs.

Insect plagues are documented in the Bible. Pliny's works on farming include descriptions of removing insects from plants by hand. A scientific study of insect pests was finally undertaken in the 17th and 18th centuries.

FIRST STEPS

The first large-scale conquest of a pest by chemical means took place in 1840 when first lime sulfur, then sulfur dusting was used in Europe to control vine powdery mildew, a disease brought over from the New World.

John Curtis was the first writer to call attention to their serious economic impact of insect pests in his book, *Farm Insects*, published in 1860. In the 1870s, various experimenters found ways of using sprayed chemicals such as calcium and lead arsenates, nicotine, pyrethrum, derris, quasia and tar oils. One mixture, called the Bordeaux mixture (copper sulfate and lime), was accidentally discovered in 1882 and is still used against vine downy mildew. Also in the 1880s, there were a number of experiments in importing natural predators against insects that crossed the seas and became major pests in a predator-free environment.

THE MAJOR PESTICIDES

In 1942, Dr. Paul Muller of Switzerland discovered the insecticidal properties of a substance first synthesized in 1874. Called dichlorodiphenyltrichloroethane, it is better known now as DDT. Dr. Muller won the Nobel Prize for this discovery, which was far more persistent and effective than any other known insecticide. During World War Two, DDT was used for killing body lice and fleas. It stopped a typhus epidemic threatening Naples. Between 1945 and 1951, several similar pesticides were discovered, includ-

ing aldrin, chlordane, dieldrin, endrin, heptachlor, methoxychlor and toxaphene.

German poison gas research led to the discovery of the organophosphorus chemicals, some of which have systemic properties: plants can absorb them without harm and then become poisonous to the pests. Some of these chemicals were extremely toxic to people and warm-blooded animals. Sprayers had to wear heavy protective clothing and breathing devices. Others seemed to harm only the pests.

Initial tests of these chemicals seemed to indicate they were the answer to all of a farmer's pest problems. Their use became the instant solution; many farmers felt that if one application was good, then two or three was better. The answer to any pest problem was found in a bag or bottle of poison.

But in the 1950s, problems started to arise from these wonder chemicals. The insects who survived the first applications bred resistant descendants. Double and triple applications were necessary where single applications had been sufficient before. Moreover, many of the pesticides were not very specific. Useful insects and pest predators were killed as easily as the intended targets.

Finally, as documented by author Rachel Carson in her seminal book, *Silent Spring*, the plants and animals protected by the pesticides proved to have a heavy pesticide buildup within them. Worse, this buildup went right up the food chain, so that small birds that ate DDT-laden grasshoppers passed the DDT up to the predators that ate them. Cows that grazed over DDT-laden fields concentrated the toxin in their meat, which was then eaten by humans. The residual effects of those years of poisoning the soil and the food chain are still around and will probably be around for decades to come.

Experts investigated the various abuses and reappraised pest control. The result has been an "integrated" approach that uses chemicals as only one part of pest-control practices.

INTEGRATED CONTROL

The United States and many other countries have now banned the use of DDT, though it is still manufactured and shipped to Third World countries that have no such laws. Milder, less human-toxic chemicals, such as malathion, are still used for crop dusting and other anti-pest operations.

Other methods of pest control include using radiation to sterilize male members of the pest species, thus causing the female members of the species to lay non-fertilized eggs. Another method induces lethal genes that mutate the insects' offspring so much they die. Some scientists are studying the use of chemical attractants that only attract the pests, which are then trapped.

A systemic fungicide has been developed that is absorbed by plants, making them fungus-resistant.

FARM MECHANIZATION

MECHANIZATION OF PLOWING AND PLANTING

The four-stroke-cycle gasoline engine was invented in the 1860s. Initially used in Germany as a stationary engine, it was later put on a wheeled cart for mobility, then by the end of the century geared and connected to the wheels to make it self-propelled. The tractor was born.

The number of tractors went from about 600 in the United States in 1907 to more than 3 million in the mid-1950s. Tractors now exceeded the number of horses and mules.

Other modern farm devices include grain combines that both cut ripe grain and separate the kernels from the straw (developed in 1938), all-purpose corn combines that plow, plant and harvest corn (developed after the Second World War), cotton pickers that separate the bolls from the seeds and bale the cotton (invented in 1927), tomato harvesters that can pick tomatoes and grade them by size (in use since 1987), and a variety of spraying machines for applying pesticides. At first, tractors were used to haul these other mechanisms, but many of them have become self-powered.

As well as equipment made directly for farm use, automobiles and trucks are used to haul farm produce, and animal trailers and airplanes are used for dusting crops, scouting land, distributing fertilizer, seeding forest terrain and controlling forest fires. Rice growers use airplanes for seeding, dropping fertilizer and spraying insecticides. Ranchers use planes to drop hay for starving cattle in times of blizzard or drought.

Airplanes are used to transport valuable livestock and perishable farm products everywhere in the world. They are particularly useful in areas like Australia and western Canada, regions extensively farmed but otherwise underpopulated.

POWER SYSTEMS

One of the most significant technological advances for farming in the 20th century was the electrification of the farmyard. It is believed that the first farm cooperative to bring electricity to farmland was organized in Japan in 1900, followed by similar groups in Germany in 1901. By the 1920s, bringing electricity to farmers had become a national interest in many countries. Now, more than 90 percent of the advanced nations have adequate electrical supplies for their farming populations.

Electricity is used for conditioning and storing grain and grass, preparing and rationing animal feed, controlling the environment in pig-rearing pens and chicken coops, and horticultural endeavors in greenhouses.

On dairy farms, electricity is used to automatically control feed rationing, cow milking and milk cooling. It is also used to operate fans and heaters for proper produce and feed storage.

CONFINEMENT MANAGEMENT

One aspect of modern animal farming that has taken efficiency perhaps a bit too far is the practice of enclosing—restricting animals to single stalls that limit all of their movement. This is called "Confinement Management."

Various animals, from cattle to chickens are kept nearly motionless and fed hormone-laced food to promote their growth until they are big enough to market. The farms themselves often look more like industrial parks full of blank-walled buildings, except that the overpowering smell of animal waste is not common in your usual office park.

By keeping the animals enclosed in one place, the farmer is ensuring that the animal is not endangered by any of the hazards of loose wire, chuckholes, toxic vegetation, or outdoor pests that could cut down the farmer's profit margin. But the price is that an animal whose ancestors ranged widely for millennia is now kept in a stall for its entire life, until the butcher's automated knife descends. This quandary of ethics versus profit is causing much debate among cattle ranchers and animal rights groups.

Confinement management saves both land and manpower, but there are many hidden costs. Cramming animals into tight spaces encourages the spread of disease. To offset this problem the animals are fed costly medicines with their feed and given regular injections. Moreover, the stressful nature of this confinement weakens the animals' systems, making them all the more susceptible to opportunistic diseases and more inclined to die early. Of course, many industrial farmers just raise animals for one or two seasons of milk or eggs, and then consider them expendable. However, the cost of replacing confined animals is far greater than on farms with pastured animals.

Most of the cattle and sheep of the world, even in advanced countries, are still kept in pastures. The cost of a fully automated enclosure system is more than many ranchers can afford; modern animal feed systems and veterinary medicine can keep animals in the field quite healthy without sealing them off from the outside world. But as the cost of enclosure mechanisms comes down and the opportunity to get rid of pasture land by selling it to land developers increases, the alternative of enclosing one's herds and automating their feeding and care, which gets you more animal from less space, becomes all the more tempting. Confinement is a "solution" with its own set of problems.

WHAT FARMS GROW

A farm's main purpose is to raise food for people to eat. This includes both crops (plants), and livestock (animals). In the 1920s and before, farmers grew a variety of crops and animals on each farm. Since then, farmers have become more and more specialized. Very few farms today raise both crops and livestock, and most raise only one crop or one animal. This trend is evident in most American and European countries, and becoming more common in Third World countries as the influence of American and European methods becomes more prominent.

NEW CROPS

For thousands of years, the three main crops of farmers in America, Europe and Asia have been corn or maize (which originated in the Americas), wheat and barley (which originated in the Near East and Europe) and rice (which originated in Asia). However, the last couple of centuries have introduced some other significant crops that are not really new, but whose value is only now being appreciated.

SOYBEANS

Soybean meal and oil have been sources of nutrition for centuries in the Orient. Imported to America around 1804, it was considered a "rare garden plant" until the early 20th century. At that point, farmers began growing it for hay, pasturage and green manure.

In the early 1930s a method was found to extract the oil without the disagreeable odor that usually attended its processing. During the Second World War soybeans became an alternate source of protein for meatless meals.

Soybeans are now used as the basis for mayonnaise, margarine, shortening, salad oil and other food products. Their non-food uses include paints, inks, oils and varnishes.

SORGHUM

Sorghum originated in Africa; it is thought to have been domesticated in Ethiopia by 3000 B.C. It spread from there throughout the Near East and all the way to India by 1000 B.C., and was carried to

China and other East Asian countries. It is known as Guinea corn, mtama and kafir corn in various parts of Africa, juar in India, kaoliang in China and sorgo in the United States.

It first came to the United States in slave ships as a grain to feed to the slaves, and by the 1930s was used as a grain, forage plant and silage for livestock. Sorghum grain is consumed by people and animals throughout the world, usually as goods baked from sorghum flour. In Africa, it is also brewed for beer.

SUGAR BEETS

The method of obtaining sugar crystals from a beet was discovered in 1747. Before then, this European vegetable had been mostly used for animal food. Development of the beet as a source for sugar was explored during the Napoleonic wars, when sugarcane from the Caribbean was no longer available in mainland Europe. Napoleon hopped on the sugar beet bandwagon and by 1814 many small factories were in operation throughout the steadily disintegrating Napoleonic Empire. After his defeat and the lifting of the blockade, the market for beet sugar declined, but it bounced back because the process had become cheap enough to compete with sugarcane. By the end of the 19th century, a third of the sugar consumed came from beets.

During and immediately after the Second World War, several developments in beet harvesting machinery made beet-raising even easier and more profitable. The hours of labor cost have been reduced to a fifth of what they were 75 years ago.

GENERAL CROPS

There are many different ways to divide up types of crops. Below, we have divided them into 11 categories, some of them edible by either people or animals, some useful as medicines or as cash crops for other purposes besides consumption. In some instances, entries fall under multiple categories.

CEREALS AND GRAINS

Cereals and grains are essentially the bread crops. They provide starch, carbohydrates and some protein and are the mainstays for much of the world's diet. Until the 1920s and 1930s, they were the mainstay of the American diet. Now, many of these grains are used as livestock feed. Cereals and grains include:

Amaranthus	Barley	Buckwheat	Corn
Emmer	Job's Tears	Millet	Oats
Rice	Rye	Sorghum	Wheat

PULSES

Pulses include legumes, peas and beans. They are typically very nutritional, many having high protein value. Vegetarians use pulses instead of meat as a protein source. Pulses include:

Beans	Chayote	Cowpeas	Groundnuts
Lentils	Lupine	Peanuts	Soybeans

ROOTS AND TUBERS

Root and tuber plants are just as their name implies, edible roots. A tuber is a root that acts as a seed pod as well as a root. Such plants are high in starch and frequently have a good concentration of protein. Roots and tubers include:

Arrowroot	Beets	Carrots	Cassava
Elephant's Foot	Jicama	Lotus	Mustard
Potatoes	Radishes	Sweet Potatoes	Taro
Turnips	Yams		

OIL CROPS

Oil crops are those that are grown more for their oil than for their eating value. The oils can be used as food additives, cooking oils, and sometimes as medicines. Some oils are high in protein and are used as meat and dairy substitutes. Many oil plants actually fall under some of the other categories listed here and are harvested both for oil and their other functions. They include:

Butternut Trees	Castor Bean (Castor Oil)	
Coconut	Flax	Mustard Seed (Mustard Oil)
Olive Trees	Palm Trees	Peanuts
Poppy Seeds	Rapeseed	Safflower
Sesame	Soybeans	Sunflowers
Tung Seeds (Tung Oil)		

FRUITS AND NUTS

Fruits and nuts are categorized as consumable seeds that grow on trees or bushes. This is their only shared characteristic. Otherwise they come in amazing varieties of size, shape, taste, nutrition and care needs. Many fruits are a good source of vitamin C. Fruits include:

Akee	Apples	Apricots
Avocados	Bananas	Baobab
Brazil Nuts	Breadfruit	Cactuses
Cashew Trees	Citron	Durian Trees
Feijoa	Ginkgo	Grapefruit
Grapes	Guava	Jackfruit
Lemons	Limes	Litchi
Longan	Loquat	Mangoes
Mangosteens	Oranges	Papayas
Peaches	Pears	Pineapples
Prickly Pears	Rambutant Trees	Sapodilla
Shaddock	Tangerines	Walnuts
Water Chestnuts	Watermelons	

VEGETABLES AND SPICES

This category covers everything from salad lettuce to exotic spices used in Oriental cooking. In general, these plants are grown on the ground. Vegetables are good sources of many necessary vitamins and roughage. Some have respectable amounts of protein. They include:

Anise	Artichokes	Black Pepper
Bottle Gourd	Broccoli	Brussels Sprouts
Cabbage	Caraway	Cardamon
Chili	Chinese Cabbage	Clove
Coriander	Cucumbers	Cumin
Dill	Eggplant	Fennel
Fenugreek	Garlic	Ginger
Leeks	Lettuce	Nutmeg
Okra	Onions	Parsley
Purslane	Saffron	Squashes
Tomatoes	Turmeric	Vanilla
Wild Rice		

FIBER PLANTS

Fiber plants are not usually consumed—they are used to make things such as clothes and rope. Many fiber plants are also sources of oil and medicine. In many cases one part of plant may be used for fiber and another used for a consumable product. They include:

Baobab Bark	Cotton	Flax
Hemp	Jute	Kenaf
Mague	Palm Trees	Ramie
Sisal		

STARCH AND SUGAR FOODS

These are the sweeteners. Diets all over the globe use sweeteners—one common trait for all humanity seems to be a sweet tooth. The following sugar foods can all be appreciated in one form or another in their natural state. They include:

Carob Trees	Palm Trees	Sorgo
Sugar Beets	Sugarcane	

FORAGE

Forage crops are used almost exclusively to feed animals. They include:

Alfalfa	Bent Grasses	Bermuda Grass
Betel Leaf	Croton Oil	Grass
Timothy (Herd's-grass)		Vetches

DRUGS, NARCOTICS, FATIGUE PLANTS

Since people started gathering plants they have tried to find ones that were magic: plants that would heal ills, raise consciousness, aid sleep or help work magic on a foe. In many cases, there was success. Modern medical researchers are still finding "folk" remedies that can help cure illness. Researchers with less altruistic agendas are still finding plants that can cause euphoria and addiction. They include:

Agave	Belladonna	Camphor	Coca
Cocoa	Coffee	Cola	Foxglove
Ginseng	Guarana	Henbane	Jimsonweed
Licorice Roots	Maté	Opium Poppies	Peyote
Rhubarb	Senna	Tea	Tobacco

UTILITY CROPS

Some plants are useful for more than eating or otherwise consuming. Some grow into useful shapes or can be used for practical purposes with a minimum of processing. They include:

Bamboo	Bottle Gourd	Rubber

ANIMALS

What would the traditional farm be without its small herd of dairy cows, the pigs in their pen, the chickens and geese running around underfoot and the plow horses whickering from their corral? Well, most farms today have very few of these elements. If they have animals, they are likely to be concentrated in one species. Most farms that raise animals produce few if any crops.

Cattle are raised for milk and, in America, South America and Europe, for meat. Other nations and cultures, such as India's, value cattle too highly as work animals and sources of milk to eat

them. Beef is a favorite meat for many people around the world, but it is seen to be a very inefficient source of protein when you compare the acreage of feed needed to raise a beef cow against the acreage needed to feed a person with grain products.

Confinement management has been used with some success (according to confinement managers) with both dairy cows and meat cows.

Sheep are mostly raised for their wool coats and for meat. However, sheep milk is becoming more and more popular in some European countries and in Australia. Some farms in these countries are now specializing in milking sheep.

Sheep are a very rugged animal that can graze where other animals would starve. The ease of raising sheep in comparison to crops and cattle caused the sociological phenomenon known as the Clearances in the early 1800s in Scotland. Scottish landlords turned all their tenant farmers out of their villages and burned the villages to the ground in order to have space for raising sheep. This is one reason why there are so many people of Scottish descent living in the United States, Australia, and Canada.

Sheep are so cheap to care for that confinement management has not really touched the sheep flocks yet. Some wool-bearing sheep are kept confined, however, as are lambs meant to be slaughtered for meat.

Swine, or pigs, are raised for meat. They are sometimes preferred for breeding because they can eat many different substances and can be kept in a relatively small area instead of the vast fields needed for cattle and sheep. Even so, pigs are frequently the victims of confinement management.

Poultry usually refers to chickens, though geese and ducks are often raised for meat. Chickens are also raised for eggs. The traditional farm generally has a hen house with a fenced-in yard where the chickens wander and peck their feed, just as their ancestors did in the wild.

Confinement management for chickens packs them into suspended cages, with padding for eggs to drop onto. Their beaks are clipped to keep them from pecking each other. Meat chickens are generally slaughtered after a couple years of life.

Horses, in some countries, notably France, are raised for meat, but in general horses are too valuable as a cash crop to eat. Farmers used to raise horses as work animals, but their major market these days is as riding animals. Unless a farmer raises horses for the purpose of riding around his fields, horses are generally raised by specialty ranchers and are not part of the usual farming mix (assuming the farm has any mix at all).

PERILS OF THE LAND

Along with insect pests, birds and rodents are menaces at two times in the growing process—when the seed is being put into the ground and during harvest time.

WEEDS

The common definition of a weed is a plant that is not valued for use (to eat or sell) or beauty, and that either encumbers the ground or hinders the growth of valuable vegetation. Weeds actively fight the growth of crops. There are many plants that can be removed from a field and never re-enter it. These are not weeds. A weed is a plant that attempts to take over or keep possession of a field where someone wants to plant something else. Some ecologists feel that every plant has value and has a place in the ecosystem, but from a farmer's viewpoint, weeds have no place on the farm.

Weeds can be plants native to an area that try to grow where they have always grown, such as the sunflower in Kansas, or they can be immigrants, brought along with some more useful plants, such as the Russian thistle in Kansas. They can even be a plant that was formerly useful, such as crabgrass, once grown as a cereal in Central Europe, now the bane of lawn growers and farmers everywhere.

This is not to say that weeds cannot be useful. There was a massive multi-car accident on Interstate Highway 5 in California in 1992 that was caused by dust storms. The dust arose from field edges that had been cultivated but not planted. If weeds had been present on those field edges, they would have held down the dust and stopped the dust storm from blinding the motorists on the freeway.

SALT CONCENTRATION

One of the biggest ongoing pollutants threatening crops all over the world is high soil salinity—a high concentration of salt in the soil. This salt is actually a collection of various mineral salts, including sodium chloride (table salt), Epsom salts, sodium bicarbonate and gypsum. Insoluble salts, such as lime and gypsum, are not real hazards to plants, but soluble salts fight with the plant seeds and roots for water. The higher the salt content, the fewer nutrients a seed can take from the soil and the fewer nutrients a root system can draw from the soil.

Salt comes from two sources: the soil itself and the water the soil is irrigated with. Most desert and semi-desert soils have a lot of salt, the result of past generations of water evaporating. Water in the same vicinity as desert soil is also likely to have high concentrations of various salts. Removing the salts from the water (desalinization) is very expensive. Also, this process essentially creates drinking water, and it seems like a waste to use drinking water on irrigation. Instead, growers and agricultural scientists are trying to find the most salt-resistant varieties of various food crops and breed them to be even more resistant to the effects of salty soil.

INDUSTRIAL POLLUTION

These are pollutants from nearby (and not so nearby) non-farming industries that affect farmland and crops. Industrial pollution takes two main forms: pollution of rivers and water tables, and air pollution causing acid rain.

Over the last thirty years, more and more factories have fled the cities for more rural areas where land and labor are cheaper. This trend started after the Second World War, and many rural factories are more than thirty years old. Moreover, mines have always been in rural areas, in many cases in mountain areas near water sources that feed the rivers that many farming areas use for their water.

Rural factories frequently disposed of the waste by dumping it in the nearest river. It's an ancient, virtually traditional, practice. When the waste was the effluvia of an 18th-century metal-working shop, this was reprehensible but not catastrophic. Modern industrial practices that use a great many toxic substances as part of the job can cause catastrophic effects on nearby water sources used as waste-disposal units. Near Cleveland, Ohio, the infamous Love Canal caught fire. Lake Erie was stripped of all its life except for a green scum.

In urban areas, citizen groups gathered and, in many cases, made their legislators pass laws that required the industries to both clean up their acts and clean up the local waterway. Lake Erie has fish in it again and the Love Canal, while not a waterway you might want to drink from, is unlikely to catch fire again.

But rural districts that had no way of controlling runoff from plowed fields getting into the nearby rivers had no procedures in place to handle industrial and mine dumping of waste products into the same rivers. Agricultural water sources are getting more and more polluted with stranger and stranger chemicals. The Environmental Protection Agency, a chronically under-staffed and under-respected agency, is trying to get some relief from this situation, but most of the activity seems to be finger-pointing with little real action.

Of course, the lack of action can be attributed to the very real industrial problems of where to put these wastes and the farmers' own lack of control of their waste products.

The other byproduct of industrial waste, acid rain, has a much more widespread effect. Acidic substances are blown out of the smokestacks of American (and many other nations') industries every day. These substances rise to the top of the atmosphere and come back down again, often mixed with other substances from other factories. The result can be a highly acidic rain that strips trees of leaves, etches the paint off of houses and settles in agricultural fields, killing the crops therein. No area is safe from acid rain. Forests unvisited by man in Canada have been attacked by pollutants from factories in New York; pollutants seem to have traveled to Florida and the Caribbean first before making the trek to Canada.

EROSION

One of the great hazards facing modern American farmers is erosion. Wind and water are eroding arable land faster than natural processes can put it back. Water erosion happens because irrigation water carries some of the soil away with it when it drains. In the earlier decades of this century, farmers were trained to create small fields with banks of soil around them that would hold in the soil. They also used contour plowing, a method that kept the plowed rows parallel with the land's depressions, so that water and soil would not drain off into the nearby riverbeds.

However, as machinery got bigger and bigger, it was more efficient to plow and harvest in long straight lines, without bothering about the contours of the land. Most modern, large farms use this bigger machinery and these newer methods, allowing for constant erosion as irrigation water carries away the soil.

This reliance on large machinery has also reduced the number of windbreaks found on modern farms. Farmers pulled up the trees and hedges that formed the windbreaks so they could have longer, straighter rows to plow and harvest. Wind that had been broken up by the windbreaks now has a clean shot at picking up the soil in a field and scattering it over the next five counties.

Worse, many farmers no longer plant ground cover on unused fields over the winter. If there is no ground cover, they can start planting faster. However, this means that winter winds have a field day picking up the unbound soil and tossing it around.

FARM FINANCE

THE EXPENSE OF RUNNING A FARM

In the late 1800s and early 1900s, land in America was free. Acts of Congress called the Homestead Acts allowed a potential farmer to claim up to 160 otherwise unused acres as a homestead. With some hard work and some weather luck, the new farmer could become self-sufficient almost immediately. With the burgeoning population in the cities, there were more and more customers for the food grown on the farms, providing an income for farmers who were close to a grain elevator and a railhead. And, in those days, more and more railheads were appearing throughout the formerly unsettled lands of the West.

The free land is gone now. Land everywhere in the country is at a premium, and the farmer has to compete with ruralizing industries and suburban housing for the land.

Moreover, the days when a farm could be run with a plow, a plowhorse and a bag of seed are also long gone. Farm machinery is becoming more complex and expensive, and seeds, fertilizer and irrigation are keeping pace with the machinery. A new farmer is looking at a mega-thousand-dollar outlay before he can start to plant a crop.

SOURCES OF INVESTMENT

Beginning farmers have great difficulty getting loans because they either don't have enough collateral or equity in other property to guarantee the loan or enough experience to justify a bank taking the risk. Farming is a very expensive proposition. In the last decade many farms have failed because a bad crop or a bad market destroyed cash flow, and the farmer could not make payments on his loans.

In the 1970s, when savings-and-loans and banks were more regulated, potential borrowers had to have co-signers for loans. In the

de-regulated 1980s, this requirement was often ignored, or else unreliable co-signers were accepted. When a farm failed, there was no one to repay the loan to the financial institution, which meant that the institution had no money, could not maintain its services to its other customers, and thereby failed. In the mid-1980s, the national farm debt was over $200 billion.

FARM SUPPORTS

Between the years 1910 and 1914, the American farming establishment was at a joyous equilibrium. Just enough farmers were producing just enough food to feed the American public and a few foreign markets, and demand was just sufficient that the farmers were receiving a good return on their investment of time and money.

In 1933, in the depths of the Depression, the Roosevelt administration pushed the Agricultural Adjustment Act through Congress. It introduced the concept of parity. The stated goal of parity is to restore the purchasing power that agricultural commodities had in the time period between 1910 and 1914.

To this end, Congress started paying farmers for their crops and, in later years, paying farmers not to grow crops. The main theory is that the government buys the crops at a parity price, then holds the crops until the world market price is high enough that the government can get its money back.

The problem with this scheme is that when the market prices are down, the government cannot sell the crops at a decent price, so it holds on to them. This is called the farm surplus. When the prices are up, the government can sell its surplus, but only by competing with the farmers' new crops. The parity arrangement can also include the farmers being paid in credits toward the stored crops, so they can sell the stored crops on their own. The exact scheme changes from year-to-year as the Department of Agriculture and the Congress try to work out the farm surplus problem. Farmers are left in the middle, wondering just what

support, if any, they will get from the government for the current year.

These supports are not unique to the United States. Other countries have similar schemes, though most involve more direct government intervention in the planting and sale of crops. Many set up tariffs on foreign crops so that they must be sold at the same price as the domestic farmers wish to sell them. Some nations deliberately sell crops at a low price just to gain a market share and drive off the higher-priced competitors, such as the United States.

The United States and the European community just underwent protracted wrangling over the issue of farm supports for European oilseeds that, according to the United States, provide an unfair advantage to European farmers in the international markets.

TYPES OF MODERN FARMS

Throughout history, as a culture increases in size and power, the size of individual farms has grown and the number of farms has fallen. In Sumer, individual planters became subservient tenants to the great temples. The independent Roman farmer of the Republic either became a massive landholder or retreated to the cities. Most of the countries of Europe have duplicated this process in their own histories. In France the process was reversed through revolution—the smaller individual farm became institutionalized by law, but France has proven to be the exception. Despite the American tradition of the rugged farmer being the backbone of the country, the United States has not proved immune to this agricultural evolution.

Between 1920 and 1985, the total number of farms (based on a Department of Agriculture criterion of a farm being any agricultural property that provides more than $1,000 in income in a year) in the United States declined from 6.5 million to under 2.2 million. At the same time, the average size of a farm has risen from under 150 acres to over 450 acres. If you ignore all of the marginal farms

that really do not support their owners, the average size of an American farm is closer to 1,000 acres. Look at the changes in the number of farms and farm sizes, as well as some other revealing factors, between the farms of 1967 and the farms of 1992.

AVERAGE FARM SIZE

	1967	1977	1987	1992 (est.)
Total Acres	1.12 bil.	105 bil.	0.99 bil.	0.97 bil.
Avg. Farm Size	355 acres	427 acres	451 acres	485 acres
Avg. Land Value (incl. bldgs.)	$168/acre	$474/acre	$547/acre	$690/acre
Total Debt	$43 bil.	$103 bil.	$154 bil.	135 bil.
Agricultural Exports	$6 bil.	$24 bil.	$29 bil.	$40 bil.
Farm Subsidies	$3 bil.	$2 bil.	$17 bil.	$10 bil.

Chart courtesy of Old Farmer's Almanac ©1992, Yankee Publishing, Inc.

In the United States, most farms are family-owned. At the same time, very few are individually-owned. This seeming contradiction is a result of families incorporating themselves for tax reasons, so that their farms are owned by a corporation in which all the stockholders are family members.

As a part of this incorporating of American farms, the number of farms has been shrinking at the same time the average size of farms has been increasing. Since 1978, the process has only accelerated. In the late 1970s and early 1980s, farmers bought up all the land they could to feed the markets of the world, only to overproduce and have the markets collapse on them.

THE DYING INSTITUTION OF THE AMERICAN FAMILY FARM

In most of the world, the family farm is still the mainstay of agriculture. The main exception is in communist and formerly-communist countries, where farms were collectivized and private ownership of farms was forbidden. However, even in ostensibly communist countries, such as China, this trend is changing back to private ownership of at least some of the farmlands worked by the farmers.

But while much of the world shifts towards democracy and looks to private ownership of farms, a different form of collectivization is happening in America. In the United States, there are no state-owned farms (except for some correctional and experimental facilities), but there are many corporate-owned farms. The people who work them have no ownership of the actual farm (unless they happen to be shareholders in the owning corporation)—they are just hired hands.

The popular American conception of the large farm family that works the land—and through the sweat on their brow and the muscle of their backs leads a healthy apple-cheeked rural existence—is now largely mythical. Big business is taking over and the farmers have had to become businesslike themselves to meet the threat of corporate absorption.

The only types of farms to increase in number since the 1960s are the largest farms (over 1,000 acres) and the smallest farms (under 50 acres). The interesting aspect of this is that in the same time the total farm acreage has actually shrunk. The large farms are essentially the result of smaller farms being purchased and combined. The small-farm increase is discussed under Subsistence Farming below.

These larger farms are owned either by major corporations that have diversified into the agricultural business, or by families who have incorporated. These family farms are now businesses, though many proprietors still try to maintain their old-style farm life.

But in most of these farm families, the draw of living in the city or the suburbs—with all the modern conveniences and a job that pays for them—is too strong an attraction for the younger members. More than half of the family farmers currently working their farms are over 60. Their children have gone on to different lives, and the chores are done by hired hands with no vested interest in the farm. The rest of the family just shows up for holidays. There are certainly exceptions to this tendency, but the trend has continued for the last thirty years.

SUBSISTENCE

Subsistence farming is simply farming to grow enough food to feed yourself and your immediate family. This is what many people around the world do every day because they have no choice. There is a bit more choice in the United States, though many small farmers are caught in a cycle where they must subsistence farm, even though they would rather be making a profit.

LIVING OFF THE LAND

Many people in the United States of America have chosen to try subsistence farming as a lifestyle choice. It is an outgrowth of the New Age and Back to Nature movements of the 1960s and 1970s. The basic premise is that the farmer only grows enough to feed himself and his family and perhaps enough other food to barter with others for cloth for clothes, mechanical work the farmer cannot do for himself, and food and other supplies (such as gasoline) that the farmer cannot grow or manufacture.

Usually, the farmer diversifies greatly, with a little grain crop and lots of different vegetables and fruits, depending on what the land and weather permit. He might keep goats and some poultry and a few pigs. Cattle are usually too expensive and time-consuming. Depending on how determined to get back to nature the farmer is, he might even invest in a plow horse instead of a tractor.

Of course, a subsistence farm is small, probably under 100 acres. Unless the farm is actually a commune or cooperative of several healthy adults, there is no reason to have more acreage.

This back-to-nature lifestyle often sounds attractive, but there are a number of pitfalls for eager farmers-to-be. For one, unless they inherit some appropriate land, they have a hard time finding good land for a farmstead. The civilized world is pretty well filled up with people. All the good farmland is owned by someone, usually someone trying to grow crops for profit. The land can be bought (often from banks who have foreclosed on a farmer-for-profit who went bust) but only for a very high price. The subsistence farmer is virtually forced to be part of the money-making rat race he is trying to avoid by becoming a farmer in order to afford the money to become a farmer.

Once the would-be farmer has his farmstead, he has put his life up as a hostage to fortune. For-profit farmers have disasters all the time: pest infestations, lack of water, toxic water, animal diseases and crop diseases are all waiting for the opportunity to strike. Many for-profit farmers have had to fold up their tents and go to the city to try to find a job because of these calamities. But a for-profit farmer, if he has been at all successful, has a bank account and credit. He can rebuild from a disaster.

The marginal subsistence farmer who wants to avoid commercial ties also avoids the financial cushion that can save him from disaster. The loss of a crop is not just a blow to the bank account; it can mean starvation for his family. It can definitely mean the loss of the farm.

PART-TIME FARMERS

Farming includes the activities both of planting, nurturing and harvesting plants and of breeding, raising and exploiting animals for the benefit of the farmer and his society. Many farmers do not raise animals except for personal use and others, such as dairy farmers, concentrate solely on animal husbandry, but both activities are essentially farming.

More than 50% of farmers "moonlight" by holding down other jobs while still working their farms. Many farmers work a regular 9-to-5 day in the nearby town as anything from a car (or farm implement) salesman to a computer programmer; they do their farming chores before and after work and on weekends.

Some farmers take these outside jobs because they need additional money to support their farms, either in lean seasons or in lean years. Other farms are actually the hobbies of people who have other incomes. "Weekend farmers" work on their farms over the weekend and hire labor to handle other daily chores, or they dump the jobs on their spouses and children. We might call such farmers "half-subsistence" farmers, since they do have a financial cushion and actually support the farm with another income. This practice is also popular with some people who work at home or as part-time consultants in anything from farming practices to computer game design.

A "gentleman farmer"is a person who farms as a hobby because he has another source of income, or delegates the actual operation of his farm to others and just reaps the rewards.

TENANT FARMING

A tenant farmer is a person who rents farmland to grow crops. In some cases the rent is paid in crops or a combination of money and crops; in other cases the contract is strictly a money rental. Many family and corporate farmers are part-time tenant farmers; they rent land from others to expand their own crops when they think it will be financially useful to do so.

Tenant farming can become a variety of slavery when the rents are so high that they can barely be paid. The tenant farmer must continue to rent and work the land while his debt to the landholder grows. This can result in the doomed cycle of the farmer unable to go anywhere else, never making enough money off the crop after paying his rent to save enough money to buy his own land.

In the American south and in colonial countries around the world this was a way of life for more than a century. It still is in many places where big landowners just collect their rents, and frequently monopolize every other aspect of their tenants' lives by owning the only local stores, and perhaps owning the machinery that the tenants must rent to cultivate their crops.

INDUSTRIAL FARMING

This term can be used to describe the cultivation techniques of some family farms (usually ones that have been incorporated into family-held corporations) and farms owned and run by outside (non-family owned) corporations. Such farms can be found all over the world, from massive corn farms in the American Midwest to rubber plantations in Malaya. The characteristics of industrial farming for the purposes of this discussion are twofold—specialized crop cultivation and cultivation of many hundreds of acres. A "factory farmer" (also called an industrial farmer) is a farmer who applies the efficiency—and callousness—of industrial production lines to farming.

SPECIALIZED CROP CULTIVATION

Most industrial farms specialize in one or two crops, such as wheat, corn, rice or certain vegetables. These are meant to be cash crops. Nothing is being grown for the use of the farmers; everything is to be sold for profit.

INTENSIFIED ANIMAL PRODUCTION—CONFINEMENT MANAGEMENT

As discussed earlier, the animal husbandry version of industrial farming calls for keeping animals in close-fitting pens or stalls at all times. Their food is automatically put into their feeding bins at the appropriate times; eggs, milk and other byproducts are taken out as needed.

The rationale behind this treatment of animals is to obtain consistent-quality meat and dairy products. This result is obtained at the expense of treating animals like machines and thwarting their every instinct. Cattle are force-fed and kept in

restrictive stalls to prevent them from bruising their meat or harming their milk flow. Calves are raised in boxes and slaughtered for veal without ever seeing the sky or even being allowed to stand up. Chickens are kept in close-fitting cages and de-beaked to keep them from harming each other. Other animals, such as swine, are also raised in confinement.

Of the major meat animals, only sheep are rarely raised in confinement, because sheep can live on land that can't be used for anything else. It's just not cost-effective to confine sheep. However, some experiments have shown that with certain hybrid breeds of confined sheep, more lambs are born per year and the sheep don't die from various range diseases and toxic plants, so some confinement management is likely.

THE ECONOMIES OF SCALE

To make the most profit, the industrial farmer has to farm as many acres as possible with the same crop so that he can economize on hiring transient help and cheaply rent the needed farm equipment and train cars or truck containers for shipping. The more diversified the crops are, the more different pieces of machinery are needed, the more shippers must be used to ship different products with different ripening dates and the more extra help must be hired to assist with different harvesting times. Moreover, with bigger harvests, the farm proprietor can get discounts on the per-item shipping and handling costs of the crops.

EFFECT ON OTHER FORMS OF FARMING

Industrial farming tends to have a missionary effect on other farms. An industrial farm is so efficient at producing its product that other farmers who wish to join in the lucrative market must adopt the same principles of specialization and expansion. This tends to turn an entire region into a collection of cash-crop farmers; other crops that are perceived as unprofitable can disappear. The lack of these other crops creates the need to import them from other areas, thus raising the prices to the consumers, including the industrial farmers and their workers.

There are places in the world where people have starved because most of the arable land was devoted to a cash crop and no one was growing basic foods for the people who grew the cash crop.

Moreover, dependence on this cash crop can be an economic disaster if the market for the cash crop goes away. Such a disaster happened in Brazil after the turn of the century when rubber, which had been a Brazilian monopoly, was transplanted to Malaya, where it could be produced by the rubber companies who would otherwise have had to buy it from the Brazilian state monopoly.

CONCLUSION

Today's farming world presents a spectrum of conditions: from food preserved by irradiation now appearing on shelves all the way to slash and burn methods still performed much the way they were thousands of years ago. Science has revolutionized food processing; refrigeration, for example, has made possible the large meat-packing plants and shipment and packaging of perishable goods. Urbanization has fostered the specialties of market gardening and truck farming. Harvesting operations have been mechanized for almost every plant product known. Breeding programs have developed highly specialized animal, plant, and poultry varieties, thus increasing production efficiency. Yet much of the world still goes hungry.

And not all of these advances are thought to be purely progressive. There have been a number of backlashes to the factory farming techniques, demonstrated by a vocal consumer market insisting on "free range" animals, organic foodstuffs, and "green" legislation to inhibit use of chemicals, pesticides, and animal hormones and antibiotics.

Some areas in the United States have tried to restrict the size of huge agribusinesses to set acreage, but many loopholes have been found to escape the restriction. In California, a succession of drought years brought about a clamoring for reform of water allotments to big farms, with many environmentalists and urban dwellers claiming that big business farms are polluting the rivers and wasting precious water. Subsidies to maintain prices, once introduced, have proved extremely difficult to end, despite many voices of opposition. Representatives of the farm-states have fought for their continuation despite the high prices for commodities.

However much the laboratory and the legal process touches our tables in the future, it's safe to say that the prime movers in the farming process for some time to come will be the land, the skies and the farmers. When the moment arrives when apple pie is brought to the table in pill form, that's the time to start a diet.

GLOSSARY

Acid Rain—Polluted rain created by industrial toxins. It has harmful long-term effects on vegetation, house paint and people.

Agricultural Science—The study of agriculture and farming as a science. Includes Agricultural Engineering, Soil Science, Plant Production, Animal Production, Economics and Management.

Agriculture—The art and science of cultivating the ground.

Animal Husbandry—The science of breeding, raising and nurturing animals.

Arable—Land that crops can be grown on.

Broadcast Sowing—Casting seeds around a plowed field in hopes that they will find a proper place, germinate and grow.

Confinement Management—The modern technique of raising animals by confining them in one stall or pen for their entire lives.

Contour Plowing—A system of plowing along the contours of a field so that the soil is not eroded away.

Cover Crop—Crops planted for the purpose of keeping fields fertile or increasing their fertility during the winter. Many cover crops can be used as fodder crops for livestock.

Crop Rotation—The process of rotating crops in a field so that a good-selling crop is rotated with crops that re-enrich the field so that the next planting of the good-selling crop will be productive.

Crops—What are grown on a farm. Usually refers just to the plants grown, though animals could be thought of as a crop, too.

Cultivation—The act of preparing ground for farming and nurturing the crops planted in that ground.

DDT (Dichlorodiphenyltrichloroethane)—The first major pesticide. Originally hailed as the answer to all of a farmer's pest control needs, it is now banned in many countries because of its harmfulness to useful insects and other animals.

Domesticated Animals—Once-wild animals that have been tamed and made useful, including dogs, cats, horses, cattle, etc.

Drill Planting—A method of planting where seeds or groups of seeds are placed into a hole that is drilled in the ground.

Ecosystem—The overall balance of plants, animals and geology in an area, which can be as small as a farmyard or as large as the entire world, depending on what you are talking about.

Erosion—In a farming context, this is the loss of topsoil and nutrients to the effects of wind and water.

Fallow Fields—Fields that have not been planted for a period in hopes that they will become more fertile the next year.

Farm—A place where crops are grown and/or animals produced for consumption.

Fertilizer—A substance used to replace needed nutrients in a planting area that have been leached away by previous use.

Field Fertility—A measure of the ability of a field to grow crops.

Fodder—Prepared food for livestock.

Forage—Growing plants that livestock eat in the field.

Herbicide—Poison used to kill weeds.

Humus—Vegetable mold. Humus can provide excellent fertilizer.

Industrial Pollution—The toxic byproducts of industry.

Insecticide—A poison used to kill insects.

Integrated Pest Management—A current method of handling infestations of pests, combining low-level insecticides, natural predators and farming practices that discourage the pests from staying. It tends to be more work, but has less potential for eventually killing the world.

Irrigation—The act of bringing water to fields to nurture plants.

Livestock—An overall term for animals raised on a farm.

Neolithic Age—The New Stone Age. A period starting about 10,000 B.C. and marked by a new form of stoneworking to make more efficient tools and the domestication of animals and plants.

Orchard—A field of trees used to grow fruit or nuts.

Paleolithic Age—The Old Stone Age. The time period from when man first began using stone tools until the New Stone Age. During this period man was a hunter and gatherer, not a farmer.

Pest—In the context of farms, a pest is any living thing that makes agriculture more difficult. It includes weeds, animals and insects.

Pest Control—Keeping animal and vegetable pests from ruining your crops.

Pesticide—A poison used to kill pests.

Plow—A device used to break up a field before planting. Probably the greatest invention of the Mesopotamian world.

Pollution—Toxic substances that get into the water, soil and air and make it difficult to grow plants. Now, mostly a byproduct of the industrial age, but animal byproduct pollution has been a problem since people first gathered in towns and cities.

Salinity—The presence of mineral salts in the soil.

SimFarm—Not merely a game, not just an educational experience—it's a way of life!

Slash and Burn—An early form of agriculture (still practiced in parts of the world) in which a patch of jungle or forest is cut down, then burned, theoretically to give the field more fertility.

Soil Science—The science of treating soil to be more fertile and the identification of fertility factors in soil.

Subsistence Farming—Farming for the sole purpose of feeding the farmer and his family.

Tenant Farming—Farming in which the farmer rents the land from the landholder, often paying the landholder with a portion of the crops grown. Also called sharecropping.

Toxins—In a farming context, any substance that poisons the soil and the plants that live in it.

Weed—A plant that grows and thrives where you don't want it to.

Windbreaks—Walls of trees or shrubs grown purposely to keep the wind from blowing soil from a farm's fields.

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